Clinical Orthopaedics

ANTHONY F. DePALMA
Editor-in-Chief



Number Eleven
Spring, 1958



J. B. LIPPINCOTT COMPANY
Philadelphia and Montreal

Distributed in Great Britain by Pitman Medical Publishing Co., Limited, London

Library of Congress Catalog Card Number 53-7647

Clinical Orthopaedics is designed for the publication of original articles offering significant contributions to the advancement of surgical knowledge.

Original, typed manuscripts, not carbon copies, and illustrations should be forwarded prepaid to Dr. Anthony F. DePalma, 1025 Walnut Street, Philadelphia 7, Pa

Manuscripts should be typed double spaced on one side of standard typewriter paper, leaving wide margins. While every effort will be made to guard against loss, it is advised that authors retain copies of manuscripts submitted. All pages should be numbered Dorland's *Illustrated Medical Dictionary* (edition 23) and Webster's *New International Dictionary* (edition 2) should be used as standard references. Scientific names for drugs should be used when possible. Copyright or trade names of drugs should be capitalized. Units of measurement, e g., dosage, should be expressed in the metric system. Temperature should be expressed in degrees centigrade. A contribution in a foreign language, when accepted, will be translated and published in English

Black-and-white illustrations will be reproduced free of charge, but the publisher reserves the right to establish a reasonable limit upon the number. Ordinarily, colored illustrations cannot be published except at the author's expense. Black-and-white photographs should be in the form of glossy prints.

Important. *These illustrations should not be defaced in any way.* Any changes desired in them should be marked on a tissue overlay. This should be done before it is pasted to the print, since it is important not to mar the print in any way. Or any changes may be indicated on a separate sheet of paper. Line and wash drawings should be on white art board, with lettering in black India ink large enough to be readable after necessary reduction. Large or bulky illustrations should be accompanied by smaller glossy reproductions of the same to facilitate their circulation among the members of the editorial board. Illustrations should be numbered, the tops indicated, and the author's name and the title of the article in brief should appear on the back. *However, this should be done lightly, so as to leave no imprint on the face of the illustration.* A separate typewritten sheet of legends for the illustrations should be supplied.

[illegible] 'pha- [illegible] anu- [illegible] text.

Bibliographies should conform to the style of the *Quarterly Cumulative Index Medicus:*

If a book:

Author's name, title of book, edition if there is more than one, page numbers if it is wished to direct the reader to a specific section of the book, city in which publisher is located, publisher's name, year of publication of book, *in the order named*

If an article in a journal:

Author's name, title of article, volume number, inclusive page numbers, year of publication, *in the order named.*

Manuscript may be submitted to us in the original language of the author. Now it is our policy to handle the translation of these articles by our office without cost to the contributor if the article is found to be acceptable for publication.

All manuscripts should be submitted with an extra carbon copy, including a short synopsis of approximately 200 to 250 words for translation into Interlingua.

Following are the general subjects of forthcoming issues of *Clinical Orthopaedics*·

The Hand, Part I, Spring, 1959

Recent Advances in Orthopaedic Surgery in Infancy and Childhood, Summer, 19

The Hand, Part II, Fall, 1959

The Foot, Spring, 1960

Clinical Physiology and Pathology of Bone, Summer, 1960

All contributors desiring to submit articles for consideration for publication on the topics listed above or in the general sections of this publication should submit them to the editor some months in advance of the date of the issue for which they are intended.

PRINTED IN THE UNITED STATES OF AMERICA

Contents

Section II

GENERAL ORTHOPAEDICS

Section III
ITEMS

1

James Knight (1810-1887) of The Hospital for the Ruptured and Crippled

PHILIP D. WILSON, JR., M.D.

The germination of orthopaedic surgery as a specialty in the United States took place during the Civil War. This fact would be easy to understand if military medicine alone had been the cause, but actually it was aided by two important preliminary steps that occurred in New York City, neither of which had anything to do with the war. In 1861, Dr. Lewis A. Sayre, a surgeon, was appointed the first Professor of Orthopaedic Surgery, Fractures, Dislocations and Clinical Surgery at the newly founded Bellevue Medical School; and on May 1, 1863, the first purely orthopaedic institution in the United States, The Hospital of the New York Society for the Relief of the Ruptured and Crippled, opened its doors.

New York then was a city of 700,000, and, though the city limits extended to the Harlem River, most of upper Manhattan was sparsely populated. However, the urban section was crowded, and hygienic conditions were not good. There were a great many poor in whom crippling diseases flourished. A contemporary account gives a vivid picture of conditions among poor children in the New York of that time:

> The hardy children we see so poorly clad, with limbs, breast, neck and head bare, and leaving the impress of their unprotected feet in the mud or snow, have, from the hour of their birth, never known what it is to enjoy the comforts of a warm bed Their first couch was a quilt spread on the floor, and covered with an old shawl, in which they found no warmth—*that* they only obtained when nursed in their mother's arms. Those who had the good fortune to be born in early summer were enabled to endure the winter with a single garment upon them, warming themselves, when in doors, at a little charcoal fire placed in a small portable furnace, and used for cooking a scanty meal of perhaps a broiled herring and a little coffee. But stern necessity soon drove them out into the streets and sharpened their intellect; and before they had advanced far in life, the precocious children commenced their vocation of begging, by dropping the head and extending the hand, even before they could speak plain enough to ask for alms. Thus early did they commence to earn their own living, and perchance to provide for dissipated parents, which latter will even sometimes send out their crippled children upon begging expeditions, knowing that their unfortunate condition will influence the donations of the charitably disposed.

These are the words of Dr. James Knight, who was instrumental in getting several prominent citizens of the city to found the first orthopaedic hospital. Its purpose was to provide "skillfully constructed surgico-mechanical appliances and other suitable apparatus for the relief of cripples, both adults and children, and so far as possible to make these benefits available to the poorest in the community.

Why did these laymen look to Dr. Knight? One would expect them to follow Dr. Sayre, who was a surgeon, prominent both medically and socially, whereas Dr. Knight was

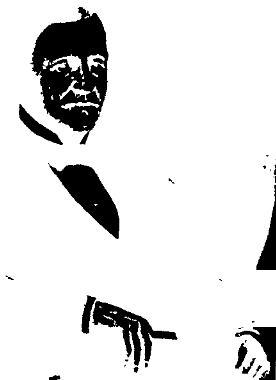


FIG. 1. Painting of Dr. James Knight. (Beekman, F.: A Historical Sketch on the Occasion of the Seventy-fifth Anniversary of the Hospital for the Ruptured and Crippled. Printed privately in New York)

only an obscure general practitioner, not even a New Yorker either by birth or by training. A graduate of the Medico-Chirurgical Faculty (of Maryland) in Baltimore, he had gone to New York City in 1835 to open his office. To be sure, he was already interested in the art of bracing or "surgico-mechanics" as he called it, since shortly after his arrival several unsuccessful suits were instituted against him for an alleged infringement of a patent right for an abdominal support used in the treatment of prolapsus uteri. But the reason was that his energy had not been wholly consumed by practice, and early in his career he had become interested in the poor and had sought to improve their condition by working as a visitor for The Association for the Improvement in the Condition of the Poor After 20 years of service for this organization, he called on Mr. Robert M. Hartley, its secretary, and pleaded the necessity for an orthopaedic hospital. This combination of Mr. Hartley's influence and Dr. Knight's enthusiasm soon won support for the venture, and it was not long before the Hospital for the Ruptured and Crippled began to receive patients.

The first building was situated at 97 Second Avenue with Dr. Knight as its resident physician and surgeon. It had a capacity of 28 beds and represented a modification of Dr. Knight's private house with the conservatory converted into a brace shop. This was a humble beginning for the first orthopaedic hospital in the United States, but Dr. Knight must have had tremendous faith in himself and his idea to bring it into being at all, especially in view of his rather meager medical qualifications. He had read widely, it is true, and in certain topics of personal interest, such as dietetics and static electricity, was an authority. But his critical judgment of what he read does not appear to have been good, even in the light of his own times. He rejected most of the newer therapeutic advances taking place about him, such as the use of bed rest, traction, plaster of Paris and surgery, and he seldom spoke at meetings of The Academy of Medicine, where his contemporaries Sayre and C. Fayette Taylor often participated in heated discussions of orthopaedic problems. Once he did read a paper on the use of static electricity, but this had resulted from the stimulation of a French visitor, who himself was an enthusiast in the use of static electricity. He published only one article, which was nothing but a brief statistical analysis of scoliosis cases with a breakdown according to sex, age and direction of curvature. In his discussion of the etiology and the treatment of this condition, Dr. Knight displays his philosophic nature and his interest in exercises and bracing. His three textbooks, two on nutrition and one on orthopaedics, show the same philosophic turn, and all lack a scientifically analytic approach Though he "believed in clinical instruction and ad-

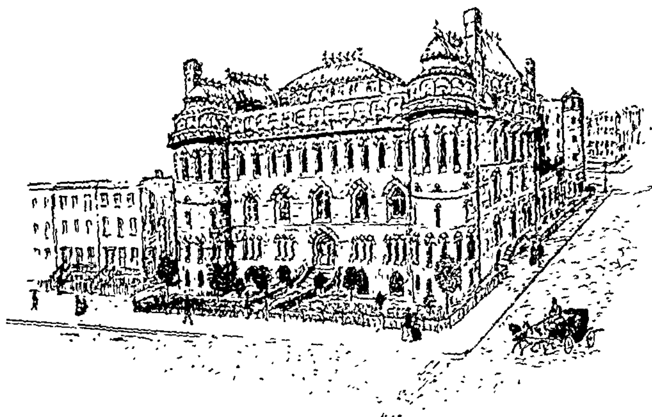


FIG. 2. The Hospital of the New York Society for the Relief of the Ruptured and Crippled at the corner of Lexington Avenue and 42nd Street. The second of four buildings, in which the hospital has been housed, opened in May, 1870. (Beekman, F.: A Historical Sketch on the Occasion of the Seventy-fifth Anniversary of the Hospital for the *Ruptured and Crippled. Printed privately in New York*)

vertised lectures," he was not successful as a teacher. Dr. Virgil P. Gibney, who worked for many years as Dr. Knight's assistant and succeeded him as surgeon-in-chief, writes that his "audience soon tired and after a season or two the clinics passed into desuetude." Gibney also writes that Knight was an "optimist in therapeutics, a firm believer in the vis 'medicatrix naturae.'" He justified his practices and ideas by sheltering himself in an institution where large numbers of cases could be observed over long periods of time, but he did not like elaborate records, and his "memory enabled him at all times to recall the good features in a case." Open discussion of clinical problems was not permitted; Dr. Knight required absolute agreement from his associates. When Dr. Gibney published a book supporting the use of operative resection of the head of the femur for tuberculosis of the hip joint, a procedure championed locally by Sayre, he was forced immediately to resign from the staff.

No, Dr. Knight's talents must be looked for in another direction than the purely scientific. Dr. Milton M. Shaffer, the second chief-surgeon of the New York Orthopaedic Hospital and himself an ardent conservative, sums up the essence of his former teacher's importance to orthopaedic surgery by saying that "all or nearly all the advance in the use of modern methods of caring for the deformed poor may be traced to New York and the personal influence of four great men, viz., Dr. James Knight, the philanthropist and organizer. . . ." Dr. Knight saw that to overcome the multiple problems of his poverty-stricken and crippled young patients, much more than simple restoration of health was needed. When a large building was constructed on the corner of Lexington



FIG. 3. A contemporary print from *Frank Leslie's Weekly*, October 30, 1875: Dr. Knight with the children in the classroom; winter garden on the roof; entrance to the hospital. (Beekman, F.: A Historical Sketch on the Occasion of the Seventy-fifth Anniversary of the Hospital for the Ruptured and Crippled. Printed privately in New York)

Avenue and Forty-second Street (where the Hotel Commodore now stands), into which the hospital moved in May, 1870, it was designed to provide a multifarious service. Besides the two large wards and the outpatient department and brace shop, there was a spacious gymnasium occupying the entire top floor, "so constructed as to be open in summer, enclosed in winter, open to the sun on all sides, and yet shaded from it overhead." Dr. Knight believed in exercise:

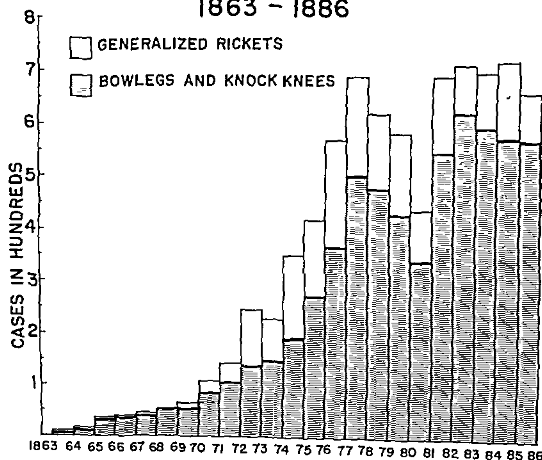
> No child able to hold up its head is ever kept in bed during the day, and all able to walk by pushing a chair before them have thus to exercise for a certain time, and those unable to walk from pain and tenderness are supplied with rolling chairs. . . . Even the most vigorous and robust constitution would inevitably be weakened and brought to a state of etiolation by long-continued repose, and in a weak constitution, the malady would be proportionately increased.

The atmosphere of a hospital was minimized, and no trained nurses were employed. Facilities were provided for religious and secular education, the latter run by the public school system of the City. Singing was encouraged. Patients were taught trades; thus rehabilitation was completed from a physical, educational, moral and occupational standpoint.

Dr. Knight obtained the co-operation of his little patients through his kind and sympathetic manner. Despite rigid enforcement of a busy curriculum, they were fond of him, and the children watched his bewigged head with curiosity. He must have been a compelling person also, since he obtained as consultants for the hospital many distinguished physicians, among whom were Willard Parker, Austin Flint and Edward G. Janeway. The Board of Managers never hesitated to back him up in any decision; nor

did they question his optimistic reports of results. This personal force of Dr. Knight was also noted by Dr. Gibney, "My faith in his accounts of cure of infantile paralysis and of hip diseases was so childlike that I found myself giving prognoses that got me into trouble as I grew older."

Dr. Knight was most accomplished in the designing and the fitting of braces. In his text on orthopaedics, many of these are described and illustrated, and there is surprisingly little difference in them from those in use today. He felt that a surgeon should be able to fit any brace himself, and no skilled mechanics were employed in his hospital. He had a weakness for static electricity and a faith in its "efficacy for all neuroses of women and many neurological diseases." The halls of the hospital "fairly reaked with ozone," according to Gibney, who himself



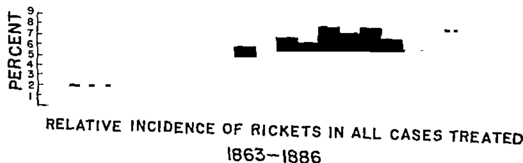


Fig 4. All cases of rickets were treated in the outpatient department. No osteotomies or osteoclases were performed between 1863 and 1886.

was influenced enough to install a static machine when the hospital moved again in 1912. In defense of Dr. Knight's position against "adventurous" surgery, one must judge him in the sense of his time when Lister's antiseptic dressing (1867) had received little notoriety, and asepsis was not practiced. Achillotomy and fasciotomy were justified, in his opinion, for fixed deformities following paralysis and in the treatment of resistant clubfeet. About 60 tenotomies were performed each year, but, while he was alive, no more extensive surgery was practiced in the hospital. Strangely enough, he was not conservative in his use of medicines and was not averse to heroic measures such as the application of "Spanish fly blisters, 16 square inches in area for 8 hours as a derivative in the acute stage of hip disease."

Of the personal life of Dr. Knight, little is known. He was born in Taneytown, Md., in 1810, the son of a manufacturer of military implements. He was only 25 when he opened his office in New York, but, except for his increasing interest in the poor, little is known about the subsequent 28 years of private practice. It is only with the organization of the Hospital for the Relief of the Ruptured and Crippled that any consecutive record can be found, and even here the personal details are entirely lacking. He served first as its resident surgeon, then as its surgeon-in-chief. He also doubled as director of the hospital. He must have been one of the first "full-time" men, since he turned over to the institution all his earnings from private patients, drawing a generous salary in return. He was married, and he and his family made their home in the hospital In fact, in the original building at 97 Second Avenue, his wife and daughter helped greatly in the operation. Thus his whole life, personal as well as professional, seems to have been dedicated to the hospital which he founded and to the poor crippled children whom he loved After a short illness, he died on October 27, 1887. His death was grievously noted by the Board of Managers, but it was practically unnoticed by the public. An obituary in the *New York World* mentions only the barest facts of his burial and contains no review of his professional attainments.

Since Dr. Knight's chief therapeutic forte was surgicomechanics, the conditions that were treated at the Hospital for the Relief of the Ruptured and Crippled during his time reflected this interest. Hernia, procidentia and varicose ulcers comprised 50 per cent of his cases in the early years and 59 per cent in the late years. Almost without exception, these were treated in the outpatient department. The inpatient population was made up almost completely of children suffering from either tuberculosis or osteomyelitis The difference between these two conditions was recognized but not sharply delineated, and it must have been further confused by the presence of many cases with mixed infection. Dr. Knight approached these problems as if they were primarily constitutional dyscrasias, and he felt that the malnutrition of his patients was the important etiologic factor. He described a "strumous diathesis" that tends to tubercular invasion (Koch did not discover the mycobacterium tuberculosis until 1882) and a "scorbutic diathesis" that leads to a much more fulminating type of disease, with an illustrative case that is typical of acute hematogenous osteomyelitis

In view of his penchant for seeking a nutritional or a metabolic fault in the host as an explanation of the conditions he saw, it is not unfair to say that Dr. Knight was metabolism-minded. Furthermore, he had to treat a great many cases of rickets. He understood the pathogenic factor of this condition as an "impairment in the osseous growth and development of the cartilage cells by an increased number of divisions," with resultant thickening of the epiphyseal cartilage plate and a thickened layer of

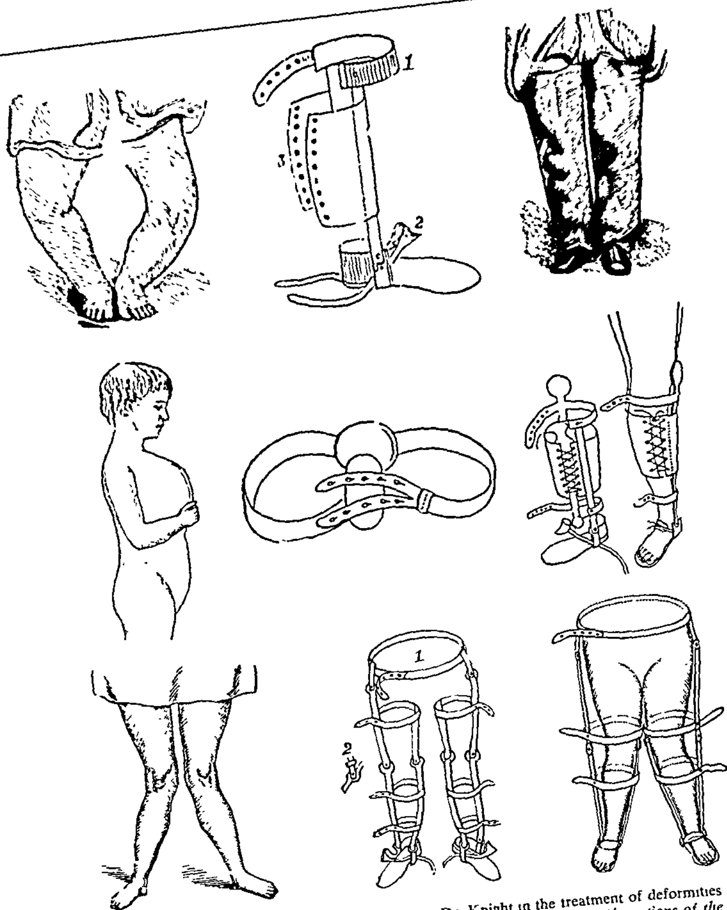


FIG. 5. Various types of appliances used by Dr. Knight in the treatment of deformities due to rickets, taken from *Orthopedia or a Practical Treatise on the Aberrations of the Human Form*, by Dr. James Knight. (Knight, J.: Orthopaedia or a Practical Treatise on the Aberrations of the Human Form, New York, Putnam)

"transition substance" under the periosteum. However, he did not fully understand the defect of calcium metabolism, since he states that "the amount of calcification may equal the normal quantity, but in rachitis it is distributed over a much larger space."

"Rachitic aberration of the normal form of the bones of the skeleton is supposed to arise from mechanical force," and "rachitic garland" and "chicken breast" were common in his experience; so also were deformities of the pelvis with projection of the sacral promontory into the pelvic strait. Weakness of the long bones was attributed to abnormal periosteal growth (Roentgen's x-rays were not used until 1895), and "the result is that the bones bend, and often break, producing great deformity and lessening the stature from curvature of the bones of the legs." "A uniform curving of the spinal column posteriorly from the cervical to the last lumbar vertebrae" was also found by Dr. Knight to be a "very common indication of rickets." He warned of occasional difficulty in distinguishing this spinal deformity from that due to Pott's disease.

As to treatment for this condition, Dr. Knight found the efficacy of bismuth superior to that of cod-liver oil, though the latter was "extolled" by German and French physicians. He writes that "our experience has not been so favorable, we having even in small doses given to patients discovered the undigested oil in the alvine evacuations." He recommended a strapping device for the relief of projecting sternum and braces for deformities of the lower limbs. At the same time, he realized that many cases of bowlegs "can be cured without instrumental aid, and as the child increases in strength from a prescribed regimen, or without interference, the deformity disappears." However, he warns against undue delay in the use of braces, since deformity is much more difficult to correct when the bones become hardened.

As a physician, the humanitarian side of Dr. Knight far outweighed the scientific. As a man, he seems to have been dedicated to the cause of the poor and to have possessed a divine confidence in his own judgment of what was good for them. To orthopaedic surgery he brought an emphasis on conservatism and furthered the art of bracing; but, most important of all, he was the first to emphasize rehabilitation in its larger sense as an integral part of this specialty.

BIBLIOGRAPHY

Annual Reports of the New York Society for the Relief of the Ruptured and Crippled, 1864 to 1887.

Beckman, F.: Hospital for the Ruptured and Crippled. A Historical Sketch on the Occasion of the 75th Anniversary of the Hospital. Printed privately in New York, 1939.

Gibney, R. A.: Biography of Dr. V. P. Gibney. Not yet published.

Gibney, V. P.: Reminiscences of orthopaedic surgeons of the latter half of the 19th century, New York J. Med., 1912.

Knight, J.: The Improvement of the Health of Enfeebled Children and Adults by Natural Means, Including a History of Food and a Consideration of Its Substantial Qualities, New York, Sackett & Mackey, 1868.

———: The Improvement of the Health of Enfeebled Children, New York, Putnam, 1875.

———: Static Electricity As a Therapeutic Agent. Paper read before Academy of Medicine, June 15, 1882. New York, Sackett & Rankin, 1882.

———: Orthopaedia or a Practical Treatise on the Aberrations of the Human Form, New York, Putnam, 1884.

———: Results of Observation in the Treatment of 2,072 Cases of Lateral Curvature of the Spine During a Period of 23 Years in the Hospital of the New York Society for the Relief of the Ruptured and Crippled. Publisher unknown.

Report of the Proceedings in Several Suits Instituted by Dr. Amos G. Hull Against James Knight, M.D., for an Alleged Infringement upon a Patent-Right for an Abdominal Supporter Used in the Treatment of Prolapsus Uteri, New York, Israel Sackett, 1839.

Shaffer, N. M.: Selected Essays on Orthopaedic Surgery, New York, Putnam, 1923.

Whitman, R.: A critical estimation of the per- [illegible] four pioneers on the devel- [illegible] in New York, [illegible] 1934.

———: Sketch of evolution of American orthopaedic surgery, Am. J. Surg. 36:553, 1937.

SECTION I

ORTHOPAEDIC SURGERY IN THE GERIATRIC PATIENT

2

Appraisal of the Geriatric Patient

RAFFAELE ZANOLI, M.D.*

Due to the continued rise of mankind's mean duration of life, the increasing number of the aged has led to a more profound and meticulous study of the surgical problem in the aged. In many statistical reports, especially Anglo-Saxon, the number of the operations in the aged is 15 per cent. In Italy, although official statistics are lacking, it may be assumed that the population aged over 60 averages about 10 per cent and, therefore, amounts to nearly 5 million.

Because of great advances in anesthesia and preoperative and postoperative care, we may regard the senile state as no positive contraindication to surgery, as was the case formerly. A number of general surgical procedures, such as those for neoplasia, gastric ulcer, hernia and prostatitis, no longer are operations of emergency but of election.

The same occurs in our field, traumatology, where the situation as regards many affections or orthopaedic deformities has not changed; nor is it likely to do so in the future.

A man with a lifelong deformity or a functional disability is not likely to seek surgical relief when aged unless he is compelled to by pain or by a disability that becomes progressively serious. However, the operative risk does not differ much from the adult's.

* Istituto Ortopedico Rizzoli, Clinica Ortopedica Universitaria, Bologna.

It is of great importance to evaluate exactly the condition of the surgical patient by investigating his deficiencies and organic reserves through careful research of the cardiovascular and the respiratory systems, the humeral conditions and the hepatic and the renal functions.

After evaluating the patient's condition accurately, it will be necessary, in preparing for the operation, to remove or to minimize all reversible changes. As for irreversible ones, such as arteriosclerosis, hypertension, coronary diseases and valvulopathies, pulmonary emphysema and chronic affections of liver and kidney, we shall proceed within our limits, setting the operative and anesthetic plan and the succeeding phase of resuscitation. If the operative hazard seems to be very high, the absolute or relative urgency for the operation will decide whether or not the risk should be taken.

As a rule we administer Pentothal Sodium in the smallest possible doses till loss of consciousness is produced, taking care that no respiratory depression occurs. Then we continue with oxygen, nitrous oxide and small quantities of Trilene or ether. However, whenever technically possible, local anesthesia is preferred, provided that the patient is psychologically in favor of it. Before local anesthesia, when there is no contraindication, a short analgesia with oxygen, nitrous oxide and Trilene is given.

In the last 2 years 30 cases were treated satisfactorily by us by means of Dogliotti's peridural anesthesia with 2 per cent Xylocaine and epinephrine. We have found this procedure to be advisable in the surgery of the aged, although sometimes it may be more difficult in the presence of arthritic stiffness, scoliosis and so on.

When employing general anesthesia, great care must be taken as to its induction and depth. In fact, induction is the most critical phase, especially for cardiopaths. It must be rapid and smooth; above all, it must prevent any respiratory difficulty or depression.

There is a wide range of indications for endotrachelic intubation. It is safe in ensuring the passage of air through the respiratory tract. In the aged, intubation often is easier because of the lack of teeth. Anesthesia must be as light as possible, for frequently a deep and prolonged anesthesia causes serious circulation and respiratory depression during the operation and may also give rise to postoperative complications. A good oxygenation must be maintained by all means. This is the best prophylaxis against accidents from anesthetics. Curare is widely employed by us, inasmuch as its use is not contraindicated by age. If muscular hypotonia, which occurs rather frequently in the aged, is present, the fractional doses are reduced in order to achieve a uniform relaxing effect on the muscles and meanwhile to spare the anesthetics considerably without provoking any danger in the amplitude of the respiratory movements. Likewise, dosages of opiates and barbiturates are reduced in the premedication. The impaired metabolism of the aged calls for caution in administering such drugs and even for excluding them from the patient in very poor general condition.

In our experience, atropine associated with morphine is preferred in the premedication, as often scopolamine causes some mental confusion and psychomotor excitement in the aged which may last some days.

Recovery and postoperative nursing are the same as for ordinary patients, i.e., possible tracheobronchial aspirations, oxygen therapy, regulation and maintenance of the electrolyte balance, restricted use of sedatives and analgesics, frequent changes of position, and a diet rich in calories and vitamins.

Finally, it is necessary to watch the patient carefully in order to note the first appearances of cardiovascular complications, particularly thrombo-embolisms. The best way in which to prevent these is by mobilization and early ambulation of the surgical patient. Other complications to be feared are the pulmonary and the respiratory ones. Often, merely a careful clinical check will prevent their inception or reduce their severity.

The incidence of fractures, particularly of certain fractures, is more common in old age, while dislocations and joint distortions become increasingly rare as age progresses until they become exceptional.

The most common fractures are those of the neck of the femur and the humerus. Fractures of the patella, the wrist and the pelvis also are more frequent in the aged, while those of the forearm and the elbow become less common. Regarding the remaining skeletal segments, no remarkable difference was observed in our study of 18,500 traumatic fractures, of which 2,500 were encountered in individuals over 60.

While dislocations appear to be less frequent, owing to senile osteoporosis, displacements of the shoulder are always of the first order and amount to 70 per cent of all dislocations in old age. Also, those associated with fractures of the neck become comparatively more common.

Distortions, on the contrary, are quite uncommon. According to our statistical reports they amount to merely 2 per cent.

The operations performed at the Istituto Rizzoli from 1945 to 1956 on subjects over 60 years of age were 1,311 out of 27,614. Therefore, the percentage is low: 4.7.

The subdivision according to the age of the patients suggests that 70 per cent belonged to the 70-year-old age group, 25 per cent to the 80-year-old group, 4 per cent to the 90-year-old group and merely 1 per cent to the over 90-year-old group. There was a marked predominance in the female: of the above total of geriatric patients, 758 (58%) were female; 554 (42%) were male.

The region operated upon most frequently was the hip: 752 (or 57.6%) operations were performed on it. The next most frequent site was the knee (8%), followed in order by the leg and the foot (6%); the spinal cord, the thigh and the elbow (4%); the shoulder and the hand (3%); the arm, the forearm and the wrist (1%). From the foregoing it appears clear that there is a definite predominance in the number of operative procedures on the lower extremity (84%) compared with those on the upper limb (15%) and the spinal cord (1%).

Our statistical study has shown also that in the surgery of the aged, operations for *traumatic injuries* predominate (63%). The most common operation is that on the femoral neck, with 620 operations (47.6%). The other traumatic lesions of the patella, the olecranon and the radial head account for 8%, and fracture-dislocations of the shoulder for 1%. The remaining ones average between 1 and 0.3 per cent.

Among the most common *orthopaedic procedures* is the incidence of arthrosis deformans of the hip with 92 operations (7%). Then come amputations, 67; tumors, 48; hallux valgus, 27; marrow compressions, 24; plastic surgery, 24; interventions on painful stumps, 23; osteoarticular tuberculosis, 23; Dupuytren's disease of the hand, 21; and lumbar hernia of the disk, 20.

We feel that results of surgery in the aged are no different from those in adult patients. Edema, joint stiffness, painful osteoporosis, are more frequent and longer lasting. Phlebothrombosis is also uncommon. On the whole, the results were as follows: good, 63.5 per cent; failures, 13.1 per cent; deaths, 1.3 per cent; results unknown, 20 per cent.

In the great majority, the incidence of death was due to cardiovascular failures or bronchopulmonary complications approximately 10 days after operation. In only 4 cases did death occur within the first 24 hours after the operation. There were no deaths during operation.

In conclusion, it is our belief that orthopaedic surgery in the aged is, and always will be, surgery of emergency, not surgery of election.

3

Anesthesia for Orthopaedic Procedures in Geriatric Patients

DONALD E. HALE, M.D.*

The increasing longevity of human beings sends more and more patients to the orthopaedist. Although many of these patients are suffering from one or several of the degenerative diseases, they should not be regarded as unsuitable candidates for anesthesia and surgery on this account. Age and senility are not the same thing; it is not the chronologic but the physiologic age that is important in estimating a patient's tolerance to stress. Men reach advanced age because of better tissues and organs than those of their fellows who have died earlier.

Many older patients have an excellent philosophic attitude and are less apprehensive and more co-operative than they were when they were younger. These patients often have fixed habits which should not be changed during their hospital stay If alcohol and tobacco are a part of the life of a patient, they should not be denied him during his hospitalization except for just cause.

Age alone imposes no absolute contraindications to the use of any anesthetic agent or method. The anesthetist should not use a different agent or an unfamiliar technic for geriatric surgery. Modification of his most familiar method is all that is required. The differences in method indicated are smaller doses, unhurried induction and more careful supervision throughout the procedure. The care, the skill and the judgment of the anesthetist are more important than his agents and machinery.

PREOPERATIVE EVALUATION

The orthopaedist, and the medical consultant if one is called, should co-operate in every way to make certain that the patient is as well prepared for surgery as possible. The anesthetist can enhance the safety of the patient if all possible defects in physiology have been corrected beforehand. Diseases of the cardiovascular system, the liver and the kidneys are encountered more commonly in the old-age group than in younger patients and increase the hazard of anesthesia. However, it should be remembered that many patients in early or middle life have similar diseases. Therefore, these disorders do not present the anesthetist with new or unusual problems.

The heart is the most important organ during the period of surgery and anesthesia, and heart disease increases the risk. When serious cardiac difficulty occurs during an operation or anesthesia, it is because of failure of cardiac output or of coronary circulation. *It is difficult to assess accurately* the ability of a heart to withstand surgery and anesthesia. In most circumstances, however, when a patient succumbs to the com-

* Cleveland Clinic.

bination of pre-existing heart disease, surgery and anesthesia, it is at an interval of several hours or days following the procedure. During surgery and anesthesia the anesthetist takes special pains to be sure that the patient is well oxygenated and that the burden on the heart is kept at a minimum. Furthermore, often he reduces the patient's need for oxygen by the use of his anesthetic agents and by carrying on the patient's respiration.

The liver and the kidneys are essential for the detoxification and the elimination of such preanesthetic and anesthetic agents as the narcotics and the barbiturates. These agents should be used with care in the presence of hepatitis or nephritis, as their effects may be much prolonged.

The anesthetic gases (nitrous oxide, ethylene and cyclopropane) and vapors (ether, Vinethene, chloroform, ethyl chloride and trichloroethylene) are eliminated unchanged, chiefly through the lungs. Therefore, they impose no burden for their detoxification upon the liver or the kidneys. However, the halogenated hydrocarbons (chloroform, ethyl chloride and trichloroethylene) may cause liver damage if used in too high a concentration or for too long a period, or if used in patients with pre-existing liver damage or in the presence of anoxia.

In many anesthesias with these agents, mild and completely reversible liver damage occurs. Pre-existing liver disease may delay the detoxification of the short-acting barbiturates, but the latter do not cause increased liver damage. Similarly, the excretion of the long-acting barbiturates may be delayed in the presence of poor renal function, but these agents do not increase kidney damage. However, ether may increase existing kidney disease.

Nitrous oxide and ethylene are completely inert within the body, and it is only the hypoxia which may accompany their use that is the source of potential harm. Cyclopropane, chloroform, ethyl chloride and trichloroethylene sensitize the automatic tissue of the heart to some of the sympathomimetic amines, among them epinephrine and norepinephrine, with the result that cardiac arrhythmias may occur if such a combination is used. These arrhythmias are chiefly ventricular, and the most serious is ventricular fibrillation. The secretion of adrenaline by the patient's adrenal medulla, through fear or pain during anesthesia, with one of these agents may produce serious cardiac arrhythmias.

PREOPERATIVE MEDICATION

Amounts of preanesthetic agents smaller than those prescribed for the young and the middle-aged are adequate in older patients. Preoperative medication should be given in a dose that is too small rather than too large, as it is an easy matter to supplement it by intravenous injections after the anesthesia has begun, if necessary.

Opiates should be given only if pain is present and then in small doses, such as 25 to 50 mg. of Demerol or 8 mg. of morphine. The barbiturates in moderate doses (pentobarbital 50 to 100 mg. by mouth 2 hours before surgery) are useful in allaying apprehension. Atropine sulfate is indicated before general anesthesia and should be given in a dose of about 0.3 mg.

MANAGEMENT OF THE ANESTHESIA

The chief complications which may follow anesthesia are the result of anoxia, the toxic effects of anesthetic agents, thrombosis and intracranial hemorrhage.

The prevention of anoxia in the geriatric patient requires adequate ventilation of the lungs, a respired atmosphere containing at least 30 per cent oxygen and an adequate oxygen transport system (blood volume, hemoglobin, red cells, cardiac output and blood pressure). One of the important functions of the anesthetist is to make sure that all these factors are studied and that deficits are remedied, when necessary, before surgery. There should be not less than 11 Gm.

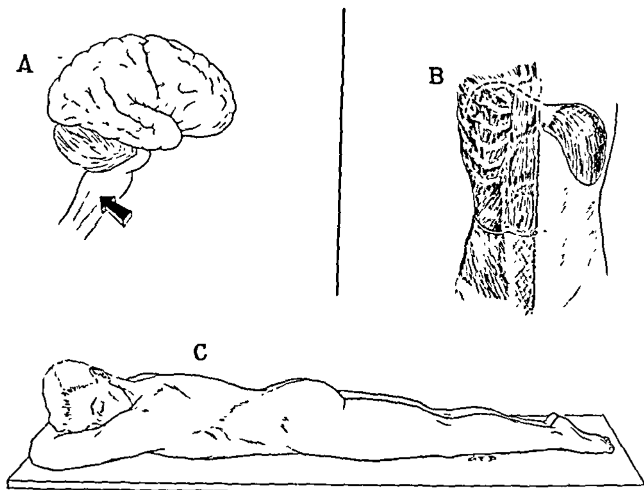


FIG. 1. Respiration in anesthesia. (A) The respiratory center is depressed by such agents as the narcotics and the barbiturates. (B) The muscles of respiration are paralyzed by high spinal anesthesia and by the muscle relaxants. (C) Respiration is decreased in the prone patient by the fact that the weight of the patient's trunk must be lifted during each inspiration.

of hemoglobin per 100 ml. of blood. However, this determination gives no information as to the total blood volume, which also should be studied or at least considered. Patients who have chronic diseases, especially those which interfere with nutrition, may have low blood volumes and hypoproteinemia. Both must be corrected. Transfusions to correct a blood-volume deficit should be given before instead of during surgery so that the possibility of transfusion reaction is not added to the hazards of age, the surgical disease, surgery and anesthesia. It is necessary, of course, to transfuse during surgery to correct blood loss, which may be estimated by the weighing of surgical sponges.

Respiration may be decreased by the anesthetic methods and agents used and by the position of the patient. The respiratory center is depressed by morphine, pentobarbital and thiopental (Pentothal Sodium). The activity of the diaphragm and the intercostal muscles is decreased by the action of the muscle relaxants and by high spinal anesthesia. When prone, the patient must lift the weight of his trunk with each breath (Fig. 1). The presence of bronchiectasis or emphysema also interferes with adequate ventilation Under these conditions it is important to help the patient to breathe, either by manual pressure on the bag of the anesthesia machine or by the use of some type of artificial respirator. Removal of carbon

dioxide is almost as important as the administration of oxygen, although in an emergency the administration of oxygen is much more important, for a patient can tolerate 15 or 20 minutes of carbon dioxide accumulation, whereas a much shorter period without oxygen would produce death.

The dangers of hypotension are the same as those of hypoxia. Therefore, the blood pressure should be observed carefully throughout the procedure. An estimate of the patient's usual blood pressure should be made by comparing blood-pressure determinations of the patient at office visits, on admission to hospital and on entering the operating room. This helps to avoid the misinterpretation of an elevated blood pressure (owing to fear or apprehension) as an evidence of a more or less serious hypertension.

Blood pressure is only an index of the tissue perfusion, but it is depended upon heavily in the conduct of anesthesia because methods of determining adequate perfusion to the brain, the heart, the liver and the kidneys are not readily available.

Blood-pressure readings should be taken at 5-minute intervals during the procedure and more frequently during the induction, as at this time the increasing depth of anesthesia is accelerating most rapidly. Especially is this true after the giving of spinal anesthesia, for the fall in blood pressure may be considerable during the first few minutes. The use of the Trendelenburg position (10°) or raising the legs of the patient may be helpful in counteracting temporarily and quickly a sudden blood-pressure fall, since the blood gravitates away from the extremities to more vital organs. Sudden changes in position should be avoided, as they may cause a decrease in blood pressure.

The toxic effects of anesthetic agents are a potential hazard in all anesthesias. All agents which the anesthetist uses are toxic and may cause death if used in large doses. However, if they are given in safe doses, and with careful observation of the effects of each before giving another, serious difficulties can be avoided.

Thrombosis may occur during or after surgery owing chiefly to a slowing of the blood stream incident to a depressed blood pressure. For this reason, it is wise to attempt to sustain what is considered to be a safe blood pressure for the patient throughout the operative and the postoperative periods. This applies to coronary thrombosis as well as to thrombosis of the peripheral veins.

Intracranial hemorrhage may result if extreme hypertension occurs during anesthesia. The causes of high blood pressure during anesthesia include hypoxia, hypercapnia, painful stimuli in light anesthesia and the use of unnecessarily large doses of the vasopressor agents. Elevated blood pressure may be controlled by correcting the cause and by the use of a ganglioplegic agent such as Arfonad.

The stomach should be empty before anesthesia. In emergencies, when anesthesia has to be given soon after a meal, the stomach should be emptied by induced vomiting or by the passing of a stomach tube before the induction of general anesthesia.

Light anesthesia (the lightest anesthesia compatible with the operative procedure) is the safest, as it interferes least with the homeostatic mechanisms, one of the functions of which is to maintain adequate blood pressure.

During surgery the patient should be supported in a comfortable position on the operating table, especially if he is crippled with such a disease as arthritis, by placing pillows beneath his head and extremities as needed to avoid strain on the involved structures.

Diabetes should be controlled as well as possible before surgery and anesthesia are undertaken. General anesthesia, especially ether, causes metabolic acidosis, *which may* be undesirable. When dextrose solutions are given to diabetic patients during anesthesia,

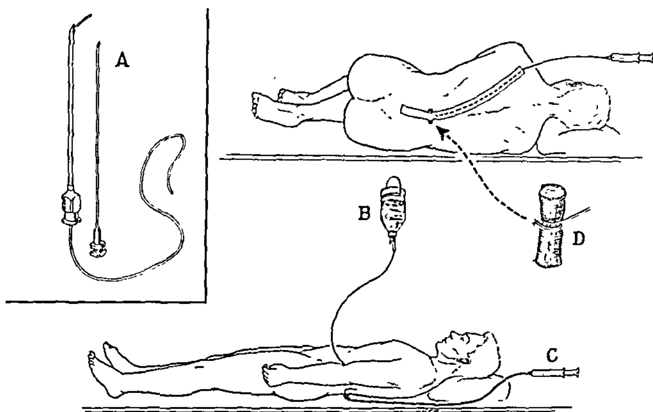


FIG. 2. Continuous spinal anesthesia. (A) Huber point Tuohy spinal needle, 17 gauge. (B) One liter of 5 per cent dextrose solution given by intravenous drip. Neosynephrine 1 ml. (10 mg) may be added as a vasopressor if needed. (C) 10-ml. syringe containing procaine 100 mg., Pontocaine 10 mg., and 10 per cent dextrose solution 3 ml., made up *to 10 ml. with distilled water. (D) The plastic tubing is wound round a rolled 4 inch x* 4 inch sponge to prevent kinking.

15 units of regular insulin should be added to each liter of 5 per cent dextrose.

POSTOPERATIVE CARE

The patient's position should be changed frequently after surgery until full recovery from anesthesia has occurred. Morphine or Demerol should be given in small doses, and the effect on respiration carefully noted. Early ambulation is beneficial to the respiratory and the circulatory systems, and should be ordered if not contraindicated. If ambulation cannot be permitted, the patient should sit up in bed or in a chair Fluids should be given slowly to prevent the overloading of the circulatory system.

METHODS OF ANESTHESIA

Local anesthesia frequently is the ideal method for small procedures and in patients who are able to give their full co-operation. Continuous spinal anesthesia and general endotracheal anesthesia (using nitrous oxide, thiopental, and a relaxant) are two of the safest and most satisfactory of the technics available.

CONTINUOUS SPINAL ANESTHESIA

One of the great advantages of continuous spinal anesthesia over the single injection is that small doses can be given, not only in inducing anesthesia but also throughout the procedure. The dose of an agent for single spinal anesthesia must be large enough to last the whole period of the operation. This may cause serious side effects Operations such as those for fracture of the hip usually can be undertaken early with safety under continuous spinal anesthesia

A 17-gauge Tuohy needle* is inserted in the mid-line of the back in the interspace below the 2nd, the 3rd or the 4th lumbar

vertebra and is advanced until its tip lies within the subarachnoid space (Fig. 2). The end of a plastic tubing (442 T, 3 ft. in length*) is inserted through the needle until about 5 cm. lies within the subarachnoid space. Then the needle is withdrawn, and a 23-gauge hypodermic needle is inserted into the free end of the tubing and is fixed to a 10-ml. syringe containing a solution in the following proportions: procaine, 100 mg., Pontocaine, 10 mg., 10 per cent dextrose solution, 3 ml., and distilled water q.s. ad 10 ml. The tubing is given one turn about a 4" x 4" sponge which has been rolled into a cylinder and then is fixed to the skin of the back. The patient is turned on his back, and 2 or 3 ml. of the mixture is injected at the rate of ½ ml. per second. The resulting anesthesia usually lasts for 1½ or 2 hours and can be supplemented by the injection of an additional milliliter as needed.

Injections as small as ½ ml. may be made in poor-risk patients and the effect noted, both in producing anesthesia and on blood pressure. Then additional small injections may be made as needed to provide adequate anesthesia while the blood pressure is observed and stabilized by the infusion of neosynephrine 10 mg. diluted in 1 liter of 5 per cent dextrose solution.

GENERAL ANESTHESIA

General anesthesia is suitable for operations on sites which cannot be anesthetized safely with spinal anesthesia, and in patients who object to spinal anesthesia. The patient is given 2 per cent thiopental intravenously in doses of 1 ml. every 10 seconds until the eyelid reflex is lost. Then 40 mg. of succinylcholine chloride (2 ml.) is injected (by vein), and the patient is given oxygen to breathe (by the mask of an anesthesia machine with gentle assistance by pressure on the bag) until relaxation is evidenced by the appearance and the subsidence of fibrillary twitching of the patient's muscles, most readily observable in the neck. A cuffed endotracheal tube is inserted into the trachea, the cuff is inflated, and the tube is connected to an anesthesia machine. Anesthesia is maintained by giving nitrous oxide and oxygen (in the proportion of 2 or 3 liters to 1), by intermittent injections of 1 to 3 ml. of thiopental and, if needed for relaxation, by the controlled infusion of a 5 per cent dextrose solution containing 1 mg. of succinylcholine chloride per ml.

* Becton, Dickinson & Co

ADJUNCTS TO SAFE ANESTHESIA

Alcohol intravenously (5% in 5% dextrose solution) frequently is of considerable help in a patient who has been in the habit of consuming alcoholic beverages. Frequently, the administration of 300 ml. of this solution will provide a light basal anesthesia which has a stabilizing effect.

An oscilloscope which provides a continuous electrocardiogram, is not a necessary but a very valuable adjunct, especially in patients who have heart disease. Changes in rhythm, such as bradycardia, may be an indication of anoxia which demands immediate correction.

The use of a respirator has been mentioned. There are several on the market, and they all accomplish controlled respiration of the patient so that the anesthetist's hands are free for the many other duties which occupy them during an anesthesia, such as taking blood pressure, adjusting intravenous fluid flow rates and checking the blood and administering it.

A large needle or a plastic catheter should be placed in a vein so that anesthetic agents, fluids or blood can be administered as needed throughout the procedure. In circumstances in which unusual blood loss is expected, more than 1 intravenous infusion should be started.

SUMMARY

Anesthesia for geriatric patients can be made safe if careful attention is given to all

the details enumerated above. Anesthesia should be induced deliberately, slowly and carefully, and with an evaluation of the effect of each dose of each agent administered. Willing co-operation among all the members of the team is essential.

Anesthesia pro Interventiones Orthopaedic in Patientes Geriatric

Summario in Interlingua

Etate avantiate augmenta a vices le risco de manovras orthopedic e anesthetic. Tamen, nulles del conditiones incontrate a etate avantiate es peculiar a iste tempore del vita, proque le morbos degenerative es etiam vidite in juvenes e personas de etate medie. Per consequente, nulle nove o specialisate technicas de anesthesia es requirite sed solmente un plus alte grado de circumspection in le evalutation e preparation preoperatori e etiam in le induction e mantenentia del stato anesthetic. In general, plus parve doses de premedication e de agente anesthetic es adequate, e attention debe esser prestate a que dosages excessive es evitate.

Duo technicas de anesthesia que es adequate e secur in le caso de patientes geriatric es continue anesthesia spinal e leve anesthesia general, con le uso de un combination de pentothal, oxydo nitrose, e un agente relaxante.

4

Fractures in the Aged

ERNEST M. BURGESS, M.D., AND ROBERT L. ROMANO, M.D.*

Advances in medicine together with improvement in living standards and nutrition have combined to produce better health and increased longevity. The resultant large segment of our population 70 years of age and older presents certain distinct medical problems not encountered in younger-age groups. Physicians are placing increasing emphasis on these problems; special medical journals are devoted entirely to the geriatric patient; some physicians limit their practice to geriatrics much as the pediatrician specializes in children's diseases.

In the field of orthopaedic surgery it has become apparent that fractures and joint injuries in this older-age group differ appreciably from those encountered in younger individuals. This difference constitutes the mechanism and the type of trauma as well as the methods of treatment and prognosis. Certain fractures occur commonly in children; in fact, some are found solely in this age group. The same is true of the geriatric patient, in whom specific fractures are characteristic, yet seldom are seen in other age groups.

The management of any fracture involves much more than the mechanical alignment of bone. With the aged, however, consideration of the entire physical condition of the patient is of paramount importance. The ultimate prognosis in these elderly people may well hinge on proper attention to general factors of nutrition, cardiac and pulmonary status, and mental and emotional response, even when the bone injury is relatively minor. In the young person, for example, a wrist which has been immobilized a sufficient period of time for fracture healing presents little problem in regaining joint motion. Also, little problem is presented in obtaining bony union or in maintaining the general nutrition and preventing decubiti. In the elderly patient these secondary factors frequently are more important than the fracture itself. One may willingly accept less than perfect anatomic reduction to obtain a prompt adequate functional result.

In the age group under consideration it is generally agreed that hip fractures are most frequent and, according to most published series, account for approximately 35 per cent of all major fractures. Colles' fractures are next in frequency (16%), and fractures of the neck of the humerus are third, comprising 14 per cent of the total. Compression fractures of the spine are fourth in order of occurrence. A wide variety of fractures make up the relatively small balance of major bone trauma. Since the vast majority of fractures in the aged involve the hip, the wrist, the humeral neck and the spine, these will be considered specifically.

Studies have been carried out by various observers to determine why elderly people are more prone to fractures at these particular locations, and also what factors underlie

* Seattle, Wash

the relatively common incidence of geriatric fractures generally. Whitfield has noted that older people are more susceptible to fractures because they "fail to make an adequate response to a hazardous situation." Therefore, these people develop a fracture either because they cannot control their motor apparatus with sufficient speed to save themselves or they can no longer decide whether or not there is a hazard and, if there is, what action to take. Thus the elderly individual with slowed mental processes due to cerebral arteriosclerosis or other cause either will not judge adequately the danger of some situation or will have such impaired reflex responses that he is unable to save himself from a fall. However, part of the problem is in neuromuscular control. Jokl, in a study of 1,704 elderly active gymnasts from 60 to 82 years of age, demonstrated statistically that the trained elderly person had better control of his motor apparatus and kinesthetic mechanism than the untrained one, or even the untrained young person. He considers that constant muscular training throughout life has an excellent inhibitory effect on all manifestations of aging. Thus, there should be a place in geriatric medicine for systematic supervised physical activity as a deterrent to the aging process and the resultant susceptibility to fractures.

The other great factor that predisposes to fractures in the aged, and the one that determines the sites of fractures in general, is osteoporosis. This condition is probably the chronic disease that most frequently is unrecognized. Its diagnosis and treatment are of maximum importance in the care of the fracture itself. After the age of 60 a rather sharp increase in fracture incidence occurs, with the sex ratio approximately 3 females to 1 male. Osteoporosis plays an important role in these statistics This osteoporosis is not due to a lack of mineral salts, as the roentgenogram would seem to suggest; rather, it is due to an imbalance in the deposition-resorption equation of trabecular molecules. All the existing trabeculae of bone are calcified normally. It is a decrease in the number of trabeculae present that produces the characteristic picture of senile osteoporosis. Thus, in the elderly individual with osteoporosis, the basic fault is a reduction of the protein matrix or framework on which the calcium salts are deposited. Since the calcium content of normal and osteoporotic bone is the same per unit weight of bone, the bone is weaker and more brittle because the trabeculae are thinner and fewer in number. These attenuated bony trabeculae can become so weak that they are no longer able to support the body; thus, collapse can occur from body weight alone. Spontaneous compression fractures of the spine, seen in severe osteoporosis, and ballooning out of the intervertebral disks into the vertebral bodies exemplify this process. Osteoporotic bone heals more slowly than normal bone, and, because of the thin cortex, internal fixation frequently is mechanically inadequate and poorly tolerated.

The etiology of osteoporosis is manifold, but the most common factors are: (1) hormonal or postmenopausal osteoporosis, which occurs in both the male and the female but is more common in the female; (2) senile osteoporosis, which probably is a combination of hormonal imbalance, a dietary or nutritional factor and atrophy from disuse; (3) disuse osteoporosis, which is the result of diminished activity of the elderly person, with secondarily decreased stress on the bone structure; and (4) another form of osteoporosis, which may occur in a single area or an extremity to which there has been trauma or pain.

This mechanism is seen frequently in fractures of the wrist and occasionally of the ankle joint, where a pain cycle is set up with disturbance of somatic and sympathetic reflex activity producing a vascular imbalance and resultant osteoporosis This is known as a reflex osteodystrophy or Sudeck's atrophy. Usually it is due to trauma. Local pain and irritation of peripheral sensory nerves initiate and maintain the patho-

logic reflex pattern. Reflex osteodystrophy is common in the elderly age groups and will be considered in more detail later.

The treatment of osteoporosis can be outlined as follows:

1. Replacement of estrogen or androgen, both of which stimulate bone formation but have a greater effect when combined than when either steroid is given alone. The sexual side effects also are reduced to a minimum by combined administration. The dosages of estrogen and androgen vary greatly, but well-balanced proprietary drugs, with an estrogen-androgen combination, are available (and vitamins also) for the treatment of osteoporosis in the aged.

2. A high protein diet is essential inasmuch as the basic problem is a lack of protein matrix. The importance of this protein is demonstrated by the fact that 20 per cent of the body protein is used in the making of bone matrix. Once this protein trabecular framework is laid down, the very nature of its chemical composition is such as to precipitate immediately an equally complex inorganic bone salt, which normally will calcify the trabecular matrix.

3. A high fluid intake is recommended to prevent a concentration of urine and hypercalciuria.

4. The patient should be mobilized rapidly, and activity should be encouraged.

5. Adequate vitamin-mineral intake is important, but excessive calcium, phosphorus or vitamin D is not necessary and may be harmful as these may produce renal calculi. In osteomalacia, vitamin D is deficient, but in osteoporosis, it is not. All the available protein matrix will calcify; thus, the need is for protein and not for excessive vitamins and minerals.

6. Vitamin C should be given the patient in large doses, as there is a definite depression of osteogenesis with a lack of vitamin C. It has been shown also that the patient who has not had sufficient vitamin C over a period of years requires larger amounts of this vitamin to compensate for the deficiency. It has been our custom to give these patients as much as 1,000 mg. of vitamin C daily.

ANESTHESIA

It is the consensus among anesthesiologists that preoperative medication in the elderly patient should be maintained at a minimum, and that after operation he should be returned to the ward as alert as possible. If regional or spinal anesthesia alone is to be used, the belladonna drugs are not necessary and, in fact, are contraindicated. Only small doses are administered with inhalation anesthesia, since the secretions of the aged are less troublesome than those of the younger patients. Atropine is preferred, since scopolamine may produce excitement, especially in the presence of pain. Demerol is recommended rather than morphine, as the depressive properties of morphine are considered to be out of proportion to its analgesic effect in elderly patients.

Koons *et al* found that episodes of hypotension were most common with spinal anesthesia, and that with this there was also an increase in the occurrence of cerebrovascular accidents, mental confusion and mild cardiac infarcts. Since the incidence of pneumonia and other respiratory complications was only slightly greater in the inhalation group, Koons *et al.* favor its use. It has also been pointed out that the elderly patient should be maintained on high oxygen tension throughout the anesthetic period. Most geriatric patients with heart disease can withstand anesthesia and surgery well so long as meticulous attention is paid to the maintenance of a high oxygen tension.

Postoperative medication is very important, and one should avoid specifically the depressive drugs, even to the point of allowing the patient to experience some moderate discomfort, pain and restlessness at night as a price for activity. Ataraxic drugs have proved to be most helpful in the postfracture recovery period. The necessary fluid balance and the electrolyte and the blood

the relatively common incidence of geriatric fractures generally. Whitfield has noted that older people are more susceptible to fractures because they "fail to make an adequate response to a hazardous situation." Therefore, these people develop a fracture either because they cannot control their motor apparatus with sufficient speed to save themselves or they can no longer decide whether or not there is a hazard and, if there is, what action to take. Thus the elderly individual with slowed mental processes due to cerebral arteriosclerosis or other cause either will not judge adequately the danger of some situation or will have such impaired reflex responses that he is unable to save himself from a fall. However, part of the problem is in neuromuscular control. Jokl, in a study of 1,704 elderly active gymnasts from 60 to 82 years of age, demonstrated statistically that the trained elderly person had better control of his motor apparatus and kinesthetic mechanism than the untrained one, or even the untrained young person. He considers that constant muscular training throughout life has an excellent inhibitory effect on all manifestations of aging. Thus, there should be a place in geriatric medicine for systematic supervised physical activity as a deterrent to the aging process and the resultant susceptibility to fractures.

The other great factor that predisposes to fractures in the aged, and the one that determines the sites of fractures in general, is osteoporosis. This condition is probably the chronic disease that most frequently is unrecognized. Its diagnosis and treatment are of maximum importance in the care of the fracture itself. After the age of 60 a rather sharp increase in fracture incidence occurs, with the sex ratio approximately 3 females to 1 male. Osteoporosis plays an important role in these statistics. This osteoporosis is not due to a lack of mineral salts, as the roentgenogram would seem to suggest; rather, it is due to an imbalance in the deposition-resorption equation of trabecular molecules. All the existing trabeculae of bone are calcified normally. It is a decrease in the number of trabeculae present that produces the characteristic picture of senile osteoporosis. Thus, in the elderly individual with osteoporosis, the basic fault is a reduction of the protein matrix or framework on which the calcium salts are deposited. Since the calcium content of normal and osteoporotic bone is the same per unit weight of bone, the bone is weaker and more brittle because the trabeculae are thinner and fewer in number. These attenuated bony trabeculae can become so weak that they are no longer able to support the body; thus, collapse can occur from body weight alone. Spontaneous compression fractures of the spine, seen in severe osteoporosis, and ballooning out of the intervertebral disks into the vertebral bodies exemplify this process. Osteoporotic bone heals more slowly than normal bone, and, because of the thin cortex, internal fixation frequently is mechanically inadequate and poorly tolerated.

The etiology of osteoporosis is manifold, but the most common factors are: (1) hormonal or postmenopausal osteoporosis, which occurs in both the male and the female but is more common in the female; (2) senile osteoporosis, which probably is a combination of hormonal imbalance, a dietary or nutritional factor and atrophy from disuse; (3) disuse osteoporosis, which is the result of diminished activity of the elderly person, with secondarily decreased stress on the bone structure; and (4) another form of osteoporosis, which may occur in a single area or an extremity to which there has been trauma or pain.

This mechanism is seen frequently in fractures of the wrist and occasionally of the ankle joint, where a pain cycle is set up with disturbance of somatic and sympathetic reflex activity producing a vascular imbalance and resultant osteoporosis. This is known as a reflex osteodystrophy or Sudeck's atrophy. Usually it is due to trauma. Local pain and irritation of peripheral sensory nerves initiate and maintain the patho-

logic reflex pattern. Reflex osteodystrophy is common in the elderly age groups and will be considered in more detail later.

The treatment of osteoporosis can be outlined as follows:

1. Replacement of estrogen or androgen, both of which stimulate bone formation but have a greater effect when combined than when either steroid is given alone. The sexual side effects also are reduced to a minimum by combined administration. The dosages of estrogen and androgen vary greatly, but well-balanced proprietary drugs, with an estrogen-androgen combination, are available (and vitamins also) for the treatment of osteoporosis in the aged.

2. A high protein diet is essential inasmuch as the basic problem is a lack of protein matrix. The importance of this protein is demonstrated by the fact that 20 per cent of the body protein is used in the making of bone matrix. Once this protein trabecular framework is laid down, the very nature of its chemical composition is such as to precipitate immediately an equally complex inorganic bone salt, which normally will calcify the trabecular matrix.

3. A high fluid intake is recommended to prevent a concentration of urine and hypercalciuria.

4. The patient should be mobilized rapidly, and activity should be encouraged.

5. Adequate vitamin-mineral intake is important, but excessive calcium, phosphorus or vitamin D is not necessary and may be harmful as these may produce renal calculi. In osteomalacia, vitamin D is deficient, but in osteoporosis, it is not. All the available protein matrix will calcify; thus, the need is for protein and not for excessive vitamins and minerals.

6. Vitamin C should be given the patient in large doses, as there is a definite depression of osteogenesis with a lack of vitamin C. It has been shown also that the patient who has not had sufficient vitamin C over a period of years requires larger amounts of this vitamin to compensate for the deficiency. It has been our custom to give these patients as much as 1,000 mg. of vitamin C daily.

ANESTHESIA

It is the consensus among anesthesiologists that preoperative medication in the elderly patient should be maintained at a minimum, and that after operation he should be returned to the ward as alert as possible. If regional or spinal anesthesia alone is to be used, the belladonna drugs are not necessary and, in fact, are contraindicated. Only small doses are administered with inhalation anesthesia, since the secretions of the aged are less troublesome than those of the younger patients. Atropine is preferred, since scopolamine may produce excitement, especially in the presence of pain. Demerol is recommended rather than morphine, as the depressive properties of morphine are considered to be out of proportion to its analgesic effect in elderly patients.

Koons *et al.* found that episodes of hypotension were most common with spinal anesthesia, and that with this there was also an increase in the occurrence of cerebrovascular accidents, mental confusion and mild cardiac infarcts. Since the incidence of pneumonia and other respiratory complications was only slightly greater in the inhalation group, Koons *et al.* favor its use. It has also been pointed out that the elderly patient should be maintained on high oxygen tension throughout the anesthetic period. Most geriatric patients with heart disease can withstand anesthesia and surgery well so long as meticulous attention is paid to the maintenance of a high oxygen tension.

Postoperative medication is very important, and one should avoid *specifically* the depressive drugs, even to the point of allowing the patient to experience some moderate discomfort, pain and restlessness at night as a price for activity. Ataraxic drugs have proved to be most helpful in the postfracture recovery period. The necessary fluid balance and the electrolyte and the blood

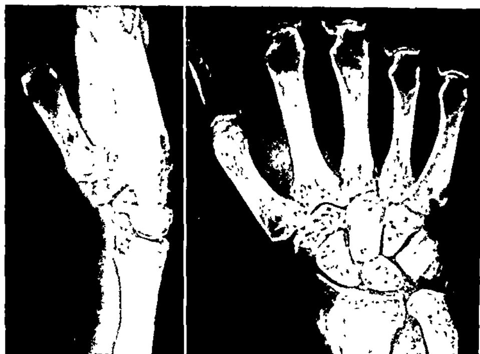


FIG. 1. Typical Colles fracture 10 weeks after reduction in elderly male. Patient has full finger, elbow and shoulder function, practically complete restoration of all wrist movements and essentially no discomfort. Moderate radial shortening and dorsal tilt are entirely compatible with adequate function. Attempts to maintain more nearly perfect osseous anatomy using multiple-pin fixation, continuous traction technics or intramedullary pins cannot be justified in this age group.

requirements are handled in the usual manner, care being taken not to overload the circulatory system by rapid parenteral administration.

TREATMENT OF SPECIFIC FRACTURES

Fractures of the Wrist. The distal portion of the radius is one area of the skeleton in which rarefaction occurs routinely with advancing years. This bone not only becomes weak but also brittle; thus, severe comminution occurs often. Although this fracture is commonplace, it does not endanger life or require prolonged hospitalization; nor does it even interfere with ambulation. Nevertheless, it should be regarded with particular care, as the end-results in the elderly patient may be crippling. The usual fracture seen in this area is about 1 inch proximal to the articular surface of the radius, with comminution and impaction of the fragments and dorsal tilt of the distal fragment. The ulnar styloid process may fracture, or the ulnar collateral ligament may be avulsed Usually, it is not difficult to obtain a satisfactory manipulative reduction, but frequently it is very difficult to maintain full correction, particularly radial length. In treating this fracture one must remember that the clinical result does not always coincide with the roentgenograms. There are patients who apparently have an excellent anatomic result, as shown by roentgenogram, yet who present a poorly functioning wrist. Others have a final position with considerable shortening and even moderate dorsal tilt but have regained excellent function without pain. The aim of treatment, then, is to obtain a wrist and a hand free of pain with approximately normal function and good appearance.

Of secondary importance is cosmesis. In the very elderly patient who has an impacted Colles' fracture with very little dorsal tilt, one may decide to accept the deformity and immobilize the patient for a short period of time without manipulation, allowing him rapid restoration of function and ignoring the slight deformity observed clinically and by roentgenogram. However, in the majority of patients, it is necessary to manipulate the wrist under brachial block anesthesia or general anesthesia; then to cast the extremity to the mid humerus with the wrist in moderate flexion and ulnar deviation, with the forearm in pronation and the elbow at 90° flexion.



FIG. 2. Typical intracapsular hip fracture in an elderly female 8 months after reduction and nail placement. The patient has resumed essentially the same activity enjoyed prior to sustaining the fracture. Remaining objective disability is very slight loss of leg length and abductor weakness with mild limp when fatigued.

It is extremely important that the cast be short enough to provide full flexion and extension of the fingers. The metacarpophalangeal joints should be completely free so that full active motion can be obtained. Finger motion should be encouraged immediately upon awakening from anesthesia. The patient should remain in the hospital overnight, at least, the arm elevated by suspension and a careful check kept on circulation. Elevation should be reduced gradually over the next several days. The position of the fragments should be checked by roentgenogram in 1 week. If the cast has become loose and the deformity is recurring, the cast can be changed carefully at this time. Otherwise, 3 weeks from the time of the initial fracture the cast should be changed and a new short below-elbow cast applied which is left on for an additional 3 weeks.

Careful attention should be directed continually to full motion of the fingers and the shoulder. In some elderly patients, in whom the fracture is quite comminuted and shortening is present, immobilization may be discontinued in approximately 4 weeks. It has not been necessary to immobilize this fracture any longer than 6 weeks at the maximum. Some authors use skeletal traction by means of the thumb or the metacarpals to maintain the length of the fragments and prevent settling. Generally, this method has been unsuccessful, inasmuch as it rarely prevents final settling of the fragments, and the risk of permanent stiffness due to the immobilization may be great. Again it should be stressed that radial shortening does not necessarily compromise a good clinical result. In an occasional patient in whom radial shortening is severe, discomfort may be felt at the ulnar styloid due to impingement at the wrist joint or to tension periostitis of the ulnar collateral ligament insertion. In these patients it is necessary occasionally to resect the distal portion of the ulna. Following this procedure the wrist and the fingers can be mobilized again quickly to obtain full function.

Neurovascular dystrophy (Sudeck's atrophy) is encountered occasionally with complaints of pain, coldness and stiffness of the fingers. If treatment has been prompt, and the postreduction care as outlined has been



FIG. 3. Typical comminuted intertrochanteric hip fracture in an elderly male 8 months after injury. The patient has been on full weight-bearing with cane assistance for the past 4 months. Activity, including standing and walking, is urged to maximum tolerance, even though union of the fracture still is not complete. The adequate internal fixation sufficiently protects the healing fractures to a degree that relatively early supervised partial weight-bearing is beneficial rather than harmful



FIG. 4. Prosthetic head replacement for intracapsular hip fracture in older diabetic patient. Illustration indicates status of prostheses 2 years after insertion. The patient walks comfortably without crutch or cane and with a barely perceptible limp. She experiences very little discomfort, even after fairly long periods of weight-bearing. Motion of the hip is nearly normal, and physical activities approach the prefracture status. Treatment of fractures by prosthetic replacement has a relatively wide field of usefulness in elderly patients.

pursued with vigor, it will not be a frequent problem, even in the arthritic, osteoporotic patient. Vigorous active mobilizing exercises, avoidance of excessive heat, adequate medication for control of pain, adrenal cortex steroids, occasional autonomic nerve blocks or surgery—all may be indicated. The basic treatment of the fracture need not be grossly altered.

Fractures of the Hip. All intracapsular fractures of the hip are treated by open surgery unless the patient is so near death that any treatment at all except splinting would be contraindicated. The blood loss and the shock incident to well-conducted internal fixation are negligible. Local, regional or general anesthesia may be used as indicated or preferred. Surgical x-ray time can be reduced by a fluoroscopic intensifier unit. Operative mortality, even in the very old and debilitated patient, is almost unknown when modern technics and management are utilized.

A great deal of study has been directed toward devising better, simpler methods of internal fixation. The triflanged Smith-Petersen nail still is most popular in this country, although telescoping appliances, with or without laterally placed plate-screw fixation, have enjoyed increasing acceptance in the past few years. These latter appliances offer a number of mechanical and physiologic advantages over the simpler nail or lag screw. However, their insertion requires somewhat longer operating time. The nail, or similar device, should be started well below the trochanteric area, placed low in the neck and a little posterior in the head. Regardless of the type of internal fixation used, all surgeons are agreed on the necessity for proper fracture reduction. The valgus position with slight intussusception of the neck should be obtained rather than cortex-to-cortex position. Forced impaction, once thought to be quite necessary, is not needed, since it will occur as a result of movement and muscle pull after the patient recovers from the anesthesia.

Upon returning from surgery and in the months of healing that follow, the hip should be protected from the stress of adduction, external rotation and prolonged flexion. Proper instruction to nurses and aides is important, especially concerning the turning of the patient. The bed spreader-bar or the shoe splints may be used as helpful adjuncts to nursing care. Prolonged sitting should be avoided. Active and gentle resisted exercises should be started early and carried out regularly. No weight-bearing should be permitted until the end of the fourth month, and full weight-bearing is withheld a total of 6 to 8 months, depending on roentgenographic evidence of progress in healing.

Primary replacement of the femoral head with a metal stem prosthesis has a definite place in treatment. We use a modified posterior approach, with section of the external rotator muscles at their insertion into the greater trochanter. The gluteus medius muscle is left intact and retracted forward. This approach is rapid, devoid of significant blood loss and tends to stabilize the prosthesis. No postoperative fixation is used. The patient is allowed up and out of bed within a week. Partial weight-bearing can be started after 3 weeks, progressing to full weight-bearing as rapidly as the patient's strength and comfort permit. The Austin-Moore, the Thompson or the Eicher prosthesis fabricated of Vitallium is used in appropriate size. Average operative time with primary prosthetic replacement is usually under 1 hour.

This operation is reserved for those fractures known to heal poorly, i.e., the vertical or varus fractures high in the femoral neck. We may also primarily replace the femoral head with a prosthesis in cases in which the patient has severe, pre-existing hip deformity or arthritis. Additionally included in this group are patients with paralysis agitans and certain individuals with hemiplegia and the occasional patient who fractures the neck of the femur with dislocation of the femoral head.

The late treatment of ununited fractures of the femoral neck and the care of those individuals who develop femoral head necrosis will not be considered. With proper management of the fracture initially, whether by appropriate internal fixation or by prosthetic replacement, approximately 85 per cent of all patients should proceed to fracture healing and/or surgical recovery without complications and with reasonable restoration of their physical activity before fracture.

Intertrochanteric hip fractures also are treated by primary internal fixation. A wide variety of well-designed nail-plate and blade-plate appliances are available. The operation is of greater magnitude than nail placement in fractures of the femoral neck; nevertheless, operative mortality and morbidity still are negligible when facilities are adequate and the meticulous attention to detail so important in elderly patients is given.

Approximately one fourth of all intertrochanteric fractures are so extensively comminuted, or the bone is so osteoporotic, that mechanical fixation by blade plate and screws is unsatisfactory. For patients with this type of fracture the well-leg traction technic is used. A Steinmann pin is inserted through each distal femur, under local anesthesia if one wishes to avoid general or block anesthesia; then each leg is placed in a well-padded long-leg cast and the pins are firmly incorporated in the plaster, as outlined in the Roger Anderson technic. After the plaster has set, a well-hip type of splint is attached to the casts, and traction, abduction and internal rotation are accomplished gradually over the next several days. Very satisfactory reduction usually is obtained without difficulty. The patient may sit up in bed and be up in a wheel chair a day or two following surgery. The casts are trimmed to permit both active ankle and foot movement as well as quadriceps setting and passive patellar massage The splint, the casts and the pins are removed after 8 to 10 weeks. Knee movement then is regained, and ambulation is permitted gradually over the next several weeks. We have had relatively little difficulty with knee stiffness, even in patients whose knees are moderately arthritic. Well-leg traction should be used in preference to open reduction when there is any question as to either the patient's ability to withstand the surgery or the mechanical suitability of the fracture for internal fixation.

Fractures of the Humerus. Comminuted fractures through the proximal humerus are frequent among older people and require a particular course of management if painless shoulder function is to be regained. As O'Brien points out, the key to this treatment is simplicity, and early motion is the goal. When a reasonable alignment of fragments has been achieved, the arm is supported gently by a sling and swathe alone, and a mild analgesic medication is given to control pain. The patient is permitted to get out of bed the day following injury and is encouraged to sit or stand as much as possible and to sleep in a semi-sitting position so that the weight of the arm exerts gentle traction. On the second or the third day the entire arm is removed from immobilization, and 5-minute supervised gravity exercises are carried out 5 to 6 times daily thereafter. Mobilization is increased as rapidly as it is tolerated, and an ordinary sling is used after the first week. Minor fragment offset and angulation or impaction are disregarded. Assisted wall-climbing exercises are started after 10 days to 2 weeks. Most patients can feed themselves comfortably and place the hand above the head after 5 to 6 weeks. After the fourth week, the sling should be discarded entirely. Healing usually is complete and motion is regained largely within 3 months. The sling and swathe are discarded as early in the postfracture period as comfort permits. When the humeral head tends to subluxate downward, it is advisable to maintain sling support for several weeks during the time that the patient is up or walking or sitting.

Concurrent with the early shoulder exercise regimen, it is most important to stress elbow, wrist and hand exercises from the start.

This early exercise management avoids specifically any fixed immobilization in casts or splints. Stiffness, disuse atrophy and pain are prevented by the no-cast, no-brace technic. While some motion may be lost in extremes of abduction and rotation due to mild malposition, functional motion is regained rapidly, and the method has been more uniformly successful than any other.

If the fracture fragments are badly displaced or angulated, closed reduction under general or brachial block anesthesia is necessary. Thereafter the sling-swathe technic is used as outlined, or, if gross instability is present, the fracture is immobilized for 2 to 3 weeks in a light shoulder spica cast with the arm so placed as to maintain fragment reduction. Then the spica is removed carefully and mobilization is begun.

Fracture dislocations of the shoulder present a difficult problem. We use closed methods of management when reduction can be accomplished. If it becomes necessary to resort to open surgery, a light metal prosthetic replacement of the head of the humerus occasionally is more satisfactory than attempting to replace the nonviable comminuted bony head. The key to successful restoration of painless function is *early mobilization* of the shoulder and the entire upper extremity.

Fractures of the Spine. In practically every instance, compression fractures of the spine are associated with osteoporosis. Trivial injury often is sufficient to cause compression; in fact, spontaneous settling or compression occurs frequently in the absence of known trauma. Back pain, with girdle or leg radiation, usually is the presenting symptom. Reflex changes, sensory deficit and muscle weakness or bladder-bowel dysfunction rarely occur, even when the compression is severe and a large kyphos or dorsum rotundum is present. Any one of a number of vertebral bodies may be involved; the lower 8 dorsal segments and the upper 3 lumbar vertebrae are the more common sites, the great majority involving T-12 and L-1.

Since gross neurologic deficit rarely occurs, and the deformity itself is not crippling, the treatment consists of the relief of pain with appropriate medication, heat and massage, the prevention of further compres-

FIG. 5. Comminuted fractures of the head and the neck of the humerus in an 84-year-old female with history of repeated cardiac decompensation. Treatment consisted of sling, swathe and early mobilizing exercises without reduction. Now, 6 weeks after injury she can raise her hand comfortably to her head and feed herself with this arm. From 3 to 4 months after fracture the patient will be expected to use the arm freely for practically all normal requirements and should have nothing more than slight discomfort. Dependent subluxation is counteracted by sling support. As rotator cuff muscle function returns with active use, the glenohumeral relationship will more nearly approach normal.



FIG. 6 Healing spontaneous compression fractures of the spine in an elderly female. The degree of osteoporosis and degenerative changes present is about average for this age group. Reduction of fractures is not attempted. Splinting by corset or light brace suffices Treatment is directed largely toward maintenance of adequate physical activity, proper nutrition and improvement of bone structure.

sion and the correction of the basic pathology, i.e , osteoporosis Attempts at reduction with hyperextension and cast fixation are to be avoided Bick and Copel demonstrated 35 cases of manipulative reduction in aged people, and in only 1 case was there roentgenographic evidence of significant correction of the deformity. This was completely lost by the time the second roentgenogram was taken, despite adequate immobilization. Thus, manipulation is unproductive of any correction of the deformity and is further contraindicated because the necessary postmanipulation immobilization will produce further osteoporosis. A well-fitted brace or brace-corset will immobilize the back sufficiently. Bed rest may be necessary for a few days, but any prolonged bed rest is contraindicated, as it will only increase the pre-existing osteoporosis. Occasionally patients develop paralytic ileus and will respond to return flow enemas, Prostigmin and the usual measures. The patient is allowed out of bed wearing the support, and an active exercise regimen is ordered. The osteoporosis is treated energetically. This should include increased activity, a high protein diet, large amounts of vitamin C, and estrogen-androgen therapy. None of these measures should be neglected, and, if carried out properly, the patient will soon be comfortable. Bracing may be discontinued when the patient is comfortable and muscle tone is good.

With this plan of management these older people shortly will become asymptomatic following compression fractures of the spine. Relief of the pain and muscle spasm must be followed by the long-range measures outlined if the patient is to remain comfortable and subsequent fractures are to be avoided. Hormone therapy particularly should be maintained for long periods.

CONCLUSIONS

Successful management of fractures in the aged necessitates a shift of emphasis away from precise restoration of bony anatomy and toward the total problem, i e., resumption of maximum activity, self-sufficiency and comfort. Total patient care is so planned and executed that normal physio-

logic processes are regained rapidly. A minor degree of local, painless functional loss can be overlooked if the patient's general mental and physical demeanor has withstood the trauma without causing or increasing invalidism.

We have outlined certain principles of general management and certain definitive technics designed to accomplish these goals.

BIBLIOGRAPHY

Albright, F., and Reifenstein, E. C.: The Parathyroid Glands and Metabolic Bone Disease, Baltimore, Williams & Wilkins, 1948.

Bernstine, M. L., and Golden, A. A.: Anesthetic considerations in geriatric patients, Geriatrics 8:246-251, 1953.

Bick, E. M.: The physiology of the aging process in the musculoskeletal apparatus, Geriatrics 10:274-277, 1955.

Bick, E. M., and Copel, J. W : Fractures of vertebrae in the aged, Geriatrics 5:74-81, 1950.

Bourne, G. H. (ed.): The Biochemistry and Physiology of Bone, New York, Acad. Press, 1956.

Ciba Foundation Symposium: Bone Structure and Metabolism, Boston, Little, 1956.

Droller, Hugo: Falls among elderly people living at home, Geriatrics 10:239-244, 1955.

Jokl, E.: Alter und Leistung, Berlin, Springer, 1954.

Key, J. A., and Ford, L. T.: Compression and extension fractures at the wrist, Geriatrics 10: 17-25, 1955.

Koons, R. A.: Anesthetic management of the aged for fractured hip surgery, Geriatrics 10: 225-228, 1955.

McLean, F. C., and Urist, M. R.: Bone: an Introduction to the Physiology of Skeletal Tissue, Chicago, Univ. Chicago Press, 1955.

O'Brien, R. M.: The treatment of fractures of the surgical neck of the humerus in the aged, Geriatrics 9:406-408, 1954.

Osteoporosis, Therapeia No. 68, 1956.

Rowe, C. R., and Detweiler, R. C.: Fractures in the aged, J.A.M.A. 162:1517-1522, 1956.

Strohl, E. Lee: Preoperative and postoperative care of the elderly, Geriatrics 8:377-384, 1953.

Vinther-Paulsen, Niels: Calcium and phosphorus intake in senile osteoporosis, Geriatrics 8:76-79, 1953.

Watson-Jones: Fractures and Joint Injuries, ed. 4, Baltimore, Williams & Wilkins, 1955.

Whitfield, J. W.: Individual difference in accident susceptibility among coal miners, Brit. J. Indust. Med. 11:126-140, 1954.

Fracturas in Patientes Geriatric

Summario in Interlingua

Le crescente segmento de nostre population con etates de 70 annos e plus presenta certe distincte problemas medical que non es incontrate in gruppos de etate plus juvene. Le tractamento de fracturas e de lesiones articular in iste individuos de etates plus avantiate require un attention primari pro factores de sollicitude infirmari general. Le precise detalios anatomic del reduction de fracturas deveni relativemente minus significative. Il pare justificate acceptar un reposition non completemente perfecte del fragmentos in le interesse de obtener un prompte e satis adequate resultato functional.

Individuos de etates avantiate deveni de plus in plus susceptibile a fracturas a causa del facto que illes non responde adequatemente a situationes hasardose. Imperfectiones del reflexos, un reducite dominio neuromuscular, errores de judicamento, e osteoporosis con resultante fragilitate del ossos, omne iste factores ha un rolo importante in explicar le alte incidentia de fracturas geriatric. Exercitios sub surveliantia systematic retarda le processo invetulatori e reduce le susceptibilitate a trauma.

Osteoporosis, le plus commun morbo geriatric, resulta del imbalancia in le equation de deposition e resorption del moleculas de osso trabecular e non de un carentia del disponibile sales mineral. Le osteoporosis debe esser diagnosticate e tractate si on vole que le fractures se reuni correctemente. Proque tanto le numero como etiam le fortia

del trabeculas es reducite a infra le norma, le osso mesme es debilitate. Iste defecto es primarimente un question de deficientia que concerne le matrice proteinic del osso. Le tractamento del osteoporosis consiste de (1) le reimplaciamento del hormones estrogenic e androgenic, usualmente administrate in combination, (2) alte valores in le ingestion de proteina con le objectivo de restablir un adequate matrice proteinic, (3) adequate provision de fluidos pro prevenir hypercalciuria, (4) adequate nivellos del ingestion de vitaminas e minerales con forte quantitates de vitamina C, e (5) exercitios active con prompte mobilisation del patiente.

Le plus meticulose attention prestate a omne detalios pre- e postoperatori insimul con le correcte selection del anesthesia rende possibile que mesmo debile patientes de etate avantiate supporta salvemente le majoritate del indicate major manovras chirurgic, como per exemplo le fixation interne de fracturas coxal o prosthetic reimplaciamentos del capite femoral o humeral.

Quatro typos de fractura—coxal, carpal, proximo-humeral, e spinal—constitue le grande majoritate del fracturas in patientes geriatric. Cata un de iste grande gruppos es considerate relative al prompte mobilisation del patiente, al rapide restauration de acceptabile grados de functionamento, e al evitation de difficultates e complicationes que frequentemente comencia per parer minor e plus tarde fini per provar se disastrose. Un ben-planate programma therapeutic servi a render le tractamento de omne iste fracturas satisfacente e gratificante.

5

Patellectomy in the Geriatric Patient

H. H. Boucher, M.D.C.M., M.Sc.*

The original work of Brooke[1] suggested that excision of the patella would be followed by good function. The results in a personal series of over 100 cases reported by the author[2] were most encouraging, and further experience has proved the value of the operation.

This chapter deals with 76 persons of 50 years of age or over when operated upon or who, having been operated upon, are now in that age group. (Only 5 were women.) The follow-up ranges from 1 to 12 years and averages 7 years.

Between 50 and 60 years of age	51
Between 60 and 70 years of age	19
Over 70 years of age	6
	76

INDICATIONS

Other than for gross trauma (13 in this series had fracture of the patella), patellectomy usually is done for chronic malacia. Only 5 patients were women, which suggested that trauma was a major factor in the development of malacia. When this is associated with instability and deformity of the knee, the indication for surgery must be made with caution. However, in well-selected cases of this nature, the operation, when followed by the use of some simple form of support such as the tensor bandage, has given worth-while improvement (Fig. 1). If there is gross instability in a relatively young and active person, a stabilizing operation such as the tenodesis of McMurray[3] should precede or follow patellectomy. This operation has been found to add a good measure of support not only when there is lateral instability but when there is anteroposterior relaxation as well.

DIAGNOSIS

Following injury to the patella not accompanied by fracture, the diagnosis may remain in doubt until the signs and symptoms of malacia are obvious. Chronic disabling malacia usually is recognized readily. The complaints are mainly pain and swelling after activity. Pain often is severe when going up or down steps or inclines. On examination excess fluid is found, with coarse patellar crepitus on motion aggravated by resistance. Following aspiration, shreds of degenerated cartilage frequently are seen floating in the synovial fluid.

OPERATION

The patella is removed readily through a marginal incision, medial or lateral, of about its own length. It is shelled out by careful, sharp dissection, protecting the tendon. Closure is done as for routine arthrotomy, and no attempt is made to "bunch" the tendon unless it has been damaged by in-

* Senior Orthopaedic Surgeon, Shaughnessy Hospital, Department of Veterans Affairs, Vancouver, B. C.; Assistant Clinical Professor, University of British Columbia.

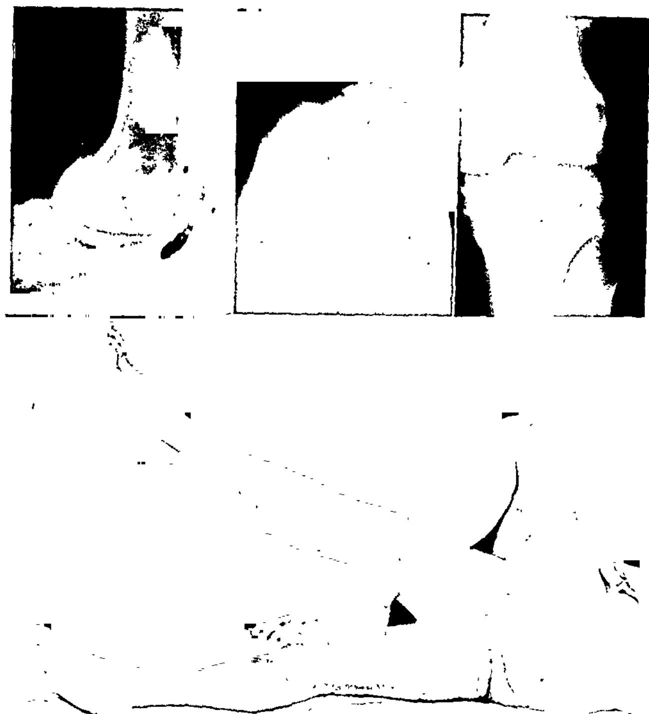


FIG. 3. (*Top and bottom*) Patient aged 61. New bone formation in patellar tendon.

The patient works at an oil refinery, climbs towers as part of his job and rides a bicycle in the evenings for exercise.

ASSOCIATED INJURY OR DISEASE

Torn meniscus	23
Ligamentous instability	8
Malacia of femoral condyles	21
Loose bodies	5

It was interesting to note the frequency of coexisting conditions in the knee. Tear of a meniscus or strained or ruptured ligaments may have been accompanied by injury to the patella and followed by malacia. Long-continued pressure of excess fluid in the joint probably is a factor in producing fibrillation of articular cartilage, and frequently chronic synovitis exists in the presence of a torn

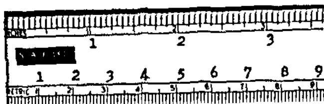


Fig. 4. Veteran 75 years of age. Patellectomy in April, 1953, with removal of loose body, probably arising from injury to the patella. Examined May, 1957. Healthy stable knee with full active range, almost full muscle volume. Is helping his son to build addition to house, states that knee is wonderful. Has no complaint. Banged knee on wooden stool to show it was not tender to kneel on.



Fig. 5. Patient aged 16. Simple strain caused fracture of patella and lateral femoral condyle: loose bodies; lateral femoral condyle; patella.

meniscus or of instability due to damaged ligaments. Loose bodies may have arisen from direct injury to the patella (Fig. 4), or, having been derived from the synovia and delivered into the joint, may have caused malacia through repeated trauma. A direct blow or a strain may have caused acute injury to the articular surfaces of the patella and the femoral condyles (Fig. 5), while injury to one may cause degeneration of the contacting surface of the other during gliding motion.

RESULTS

1. **Health of Joint.** It was common to find that the usual preoperative complaint of pain and swelling had disappeared. It was rare to find heat, soft-tissue thickening or excess fluid, and crepitus was less and not infrequently absent.

2. **Motion.** Full active extension without lag could be anticipated and usually was not difficult to obtain. A temporary lag was not uncommon, due to inhibition, but only 3 showed a permanent lag, and this was less than 5° in 2 cases and 10° in the other. Flexion was obtained readily following excision for malacia, but it was delayed and sometimes limited after immobilization following fracture and rupture of the tendon and the aponeuroses.

3. **Muscle Volume.** Only 10 patients recovered full quadriceps volume, and slight to moderate atrophy was common. The greatest loss was over 2 inches in volume, the average being .71 inches. Failure to recover full volume in an active patient was not disabling, as with good tone there seemed to be ample power.

4. **Power.** It was common for patients to complain of weakness early in their convalescence. Generally this occurs in arthrotomy of the knee but persists longer after patellectomy, the chief complaint being a fear of sudden collapse in flexion. This complaint disappears gradually and rarely persists, so that on making follow-up examinations one was impressed by the power and the confidence displayed. On direct ques-



FIG. 6. Railway employee aged 53. Gross malacia of patella. Operation—*patellectomy* March, 1952. Examination June, 1957. Returned to former occupation of switch foreman. *Jumps on and* off boxcars without trouble. Knee healthy, stable, powerful, full active range, ½-in. atrophy of thigh. No tenderness on kneeling.

tioning a few patients stated that they had noticed some weakness in getting up from a sitting position, but no one voluntarily made this complaint.

5. **Activity.** These patients remained active in keeping with their age—some surprisingly so. Several stated that the knee operated upon was now *the best knee. If* active prior to surgery, it was not uncommon for the patient to return to his former occupation (Fig. 6).

INTERESTING CASES

Mrs. A. C. At the age of 60 she complained of a grossly swollen and painful knee of several years' duration. Clinical examination suggested chronic villous arthritis. In November, 1950, when patellectomy and synovectomy were done, there was gross destruction of the patella, and the shaggy, faded chocolate-brown appearance of the synovia suggested that the clinical diagnosis was correct. The report of 2 pathologists, however, was that it was tuberculosis

The patient was seen in April, 1957. At this time the knee was healthy with full active extension, flexion to 60°, stable, no crepitus and ½-inch atrophy of the quadriceps. The pathologic sections were reviewed by the same 2 pathologists, and, in spite of the clinical picture today, they feel certain that their diagnosis was correct. There was no evidence of tuberculosis elsewhere in the body at the time of surgery, and no antibiotic treatment was given.

Mrs. M. M. W. This short, heavily-built and overweight woman of 42 (weight 200 lbs) had a right patellectomy done in 1949 for malacia, with an excellent result. She returned in 1956 with clinical evidence of gross malacia in her other knee, and the patella was removed with what would appear to be a good early result.

Mr. A. S. In 1953, at 64 years of age, patellectomy and synovectomy were done in the left knee for a clinical diagnosis of chronic villous arthritis, confirmed by pathologic examination. The patient was examined in April, 1957, then 68 years of age, and the knee was healthy and stable, with full active extension and almost full flexion with no crepitus. He states, "It is a good knee."

Mr. M. M. In July, 1951, at 58 years of age, he suffered a compound fracture of the left patella. The lesser fragment was removed elsewhere, and the tendon was repaired. Infection followed, and he was referred for treatment. Examination showed profuse discharge of thick pus, and there was osteomyelitis of the remaining fragment with 2 sinuses and a visible defect in the patellar tendon. In December, 1951, the remaining fragment was removed, no attempt being made to repair the tendon. Marked reaction of soft tissue and a gross defect in the patellar tendon were seen. No cast was used, and active exercise was begun almost immediately.

Late in January, 1952, rehabilitation was begun, during which the patient fell on February 6 and suffered an intertrochanteric and subtrochanteric fracture of the same femur. A Smith-Petersen nail and a McLaughlin plate were used Infection of the wound was a complication. On May 27, 1952, he fell while exercising and fractured the distal shaft of the same

femur. This was treated conservatively. On November 15, 1952, he was written off by the Workmen's Compensation Board on the basis of time loss and given a P.P.D. award. At that time the knee seemed to be healthy, with active extension to 170°, no lag, flexion to 70° and fair strength.

Mr. C. J. H. Fractured patella in 1944; only 30° of flexion following open reduction. Refractured patella in 1946; followed by excision. Many intra-articular adhesions were found at operation. Now 55 years old, he is a butcher and also runs a farm. The knee is healthy, active range of motion is from 180° to 70°, there is ½-inch atrophy of the thigh, and the patient is very pleased with his knee.

Mrs. E. A. On June 20, 1954, at the age of 68, this woman suffered a comminuted fracture of the patella with complete rupture of the aponeuroses. The patella was excised, and the tendon and the aponeuroses were repaired. When examined on May 8, 1957, then 71 years old, this patient had a healthy, stable, powerful knee with full active flexion and extension.

Mr. R. S. B. (age 74). This patient suffered a gunshot wound in World War I, the result being a short right leg and a stiff knee. In 1937 he fell and fractured the right patella. Open reduction was done, and extension was complete with flexion limited to 110°. In 1952 he fell again and fractured the same patella with a complete rupture of the aponeuroses. The patella was removed, and the aponeuroses were repaired with fascia lata. He was examined in May, 1957. The knee is healthy with flexion to 100° and a lag of extension of 10°. The patient complains of weakness and would prefer his knee as it was prior to his last injury.

Mr. H. J. C. In November, 1952, at 66 years of age, patellectomy and meniscectomy were done. Malacia of patella, medial femoral and tibial condyles and a torn medial meniscus were found. Examined on May 7, 1957, he had a healthy knee, full range of motion, full volume of muscle, no crepitus. His present occupation is census-taker, on foot.

SUMMARY

The results of patellectomy in a group of 76 persons of 50 years of age or over are given. The main indications for operation are fracture and malacia. The diagnosis is made on physical findings. The operation is simple, the patella being "shelled" out carefully by sharp dissection, and, unless the tendon is torn, no "bunching" is done. A splint is not usually applied, and early activity is encouraged. The average time of return to moderate activity is somewhat longer than after simple arthrotomy, even in younger patients, and improvement generally continues over a period of 1 or more years. Postoperative rupture of the tendon occurred twice, and new bone formation in the tendon was troublesome in 1 patient. Malacia of the patella frequently is associated with a torn meniscus or damaged ligaments, and varying degrees of degeneration of the femoral condyles are common. The results were uniformly good, with disappearance of excess fluid and pain and a lessening of crepitus. Tenderness on kneeling was seldom a complaint and rarely persisted. A few complained of weakness in getting up from the sitting position early in the convalescent phase, but in the final examinations for this report no patient offered this complaint voluntarily. As these patients reported on request, for long-term follow-up enquiry, it was obvious that they were very willing to come and were well pleased with the result of operation. Thus, to visit one of these patients, or to have one turn up at the office, became one of the brighter moments of the day.

CONCLUSION

Patellectomy in the geriatric patient is a good operation.

REFERENCES

1. Brooke, R.: The treatment of fractured patella by excision: a study of morphology and function, Brit. J. Surg. 24:733, 1936-37.
2. Paper read at the meeting of the English-speaking orthopaedic surgeons of the world in London, England, 1952.
3. McMurray, T. P.: A Practice of Orthopaedic Surgery, ed 1, p. 52, London, Arnold, 1937.
4. Visit of Sir Reginald Watson-Jones to Shaughnessy Hospital, 1950.

Patellectomia in le Patiente Geriatric

Summario in Interlingua

Ablation del patella esseva effectuate in 76 patientes de etates de 50 annos o plus. Le principal indication esseva malacia. Solmente 13 habeva suffrite lesiones ossee. Le serie total includeva non plus que 5 feminas. Isto suggere que trauma es un factor major in le disveloppamento de malacia. In determinar si o non patellectomia es indicate, le etate del patiente es minus importante que le stato de su sanitate e le grado de su activitate. Le genu deberea esser stabile. Un deformitate var suggere le presentia de alterationes degeneratori que se provara probabilemente como progressive. Le operation es simple. Le patella es simplemente "eco-chleate" per acute e caute dissection con le minimo possibile de insulto al tendine patellar. Iste tendine non es fasciculate, excepte quando illo es severmente ledite. Nulle apparato es usate post le operation, excepte quando le tendine ha essite gravemente vulnerate o quando le sanguination post-operatori es excessive o persistente. Aspiration e application de apparatos pote prevenir le formation de sinos. Activitate es tosto incoragiate, providite que nulle complication lo prohibi. Ruptura del tendine occurreva in duo patientes durante lor convalescentia. Illo esseva tractate per reparo aperte con bon resultatos. Neoformation de osso in le tendine non es incommun. In rar casos illo attinge un grado invalidante. In un patiente il esseva necessari remover un portion marginal, sed quando iste patiente esseva re-examinate sex annos plus tarde, ille habeva nulle gravamines. Le resultato final in patientes active es usualmente bon. Le signos e symptomas de malacia dispare o se reduce. Le restablimento del complete extension active con bon fortia e un bon grado de flexion pote esser expectate. Un certe grado de persistente atrophia del quadricipite es commun, sed bon tono e bon fortia co-existe con illo. Le autor opina que iste operation, portate a su attention per le labor de Brooke, es un manovra de valor positive.

6

End-Result Study of Vitallium Cup Arthroplasties of the Hip

HARRY E. EMMEL, M.D., JOHN F. LECOCQ, M.D., EDWARD A. LECOCQ, M.D., DARRELL G. LEAVITT, M.D., HARRY L. LEAVITT, M.D., KIRK J. ANDERSON, M.D., HENRY H. NASH, M.D., AND J. GARTH MOONEY, M.D.*

The end-result study of Vitallium cup arthroplasties of the hip was done on cases on which the authors operated over a 16-year period. The first operations were performed in 1940; the last cases included in the group were done in June, 1956. After examination of these cases we found that 101 patients qualified for this particular end-result study. Cup arthroplasties were done on 8 of these patients on both sides, making a total of 108 cup arthroplasties performed on 101 patients.

The patients in this series varied in age from 16 to 72 years. Seventy-two of these patients were between the ages of 30 and 70. Sixty-five of the 101 patients were males.

In the majority of cases the patients presented themselves with the chief complaint of progressive disabling pain in the hip. The average duration of symptoms was 8.7 years. In a few cases the hip joints were fused solidly by bony ankylosis. In other cases there was only a few degrees of motion, which was extremely painful. Ninety-two per cent of the cases had flexion deformity of at least 25°, and usually there was some degree of adduction as well. One extreme case presented a flexion deformity of both hips with fixed ankylosis in 130° of flexion. In all cases there were varying degrees of limitation of abduction and internal and external rotation. The average follow-up period was 3.9 years.

In 55 patients the diagnosis was osteoarthritis without specific cause. Of these 55, 14 had bilateral hip-joint involvement.

Table 1 indicates the diagnosis in the cases reviewed for follow-up study. Septic

TABLE 1. DIAGNOSIS OF HIP PATHOLOGY IN 101 PATIENTS

	PATIENTS
Osteoarthritis, unknown cause	55
Septic arthritis	8
Congenital dislocations†	8
Slipped epiphyses	7
Arthrokatadysis (Otto's pelvis)	2
Old Perthes' disease of the hip	2
Rheumatoid arthritis with Marie-Strumpell spine	12
Fracture dislocations	5
Fracture of neck of femur with avascular necrosis	2

† Those hips showing mild or moderate degree of acetabular dysplasia and subluxation were classed in the group of osteoarthritic hips.

* The authors are on the staff of the Seattle Orthopaedic Clinic, Seattle, Washington.

arthritis accounted for 8 cases in our group.

A history of congenital dislocation with apparent successful early treatment accounted for 8 cases. Four of these 8 congenital hip dislocations were bilateral. One case revealed bilateral shallow acetabuli of marked degree without actual dislocation.

There were six cases with definite history of a slipped capital epiphysis; in this group 3 cases were bilateral.

Two patients presented a marked degree of arthrokatadysis, or Otto's pelvis. However, in several of the cases of osteoarthritis without definite cause there were varying degrees of intrapelvic protrusion of 1 hip and sometimes both hips.

An old history of Perthes' disease of the hip accounted for 2 cases in our series.

There were 12 cases of definitely diagnosed rheumatoid arthritis. In all 12 there was some degree of involvement of the spine, the sacro-iliac joints and some of the other joints in the body. Six of them had painful involvement of both hips. In 1 case there was complete ankylosis of both hips without pain, and the operation was performed to correct the extreme amount of deformity.

Fracture dislocations of the hip were the cause of degenerative changes in 5 cases.

Aseptic necrosis of the head of the femur following fracture of the femoral neck is accountable for the symptoms in 2 cases. Those cases of avascular necrosis following fracture of the neck of the femur, which required a Colonna or a Whitman reconstruction using a Vitallium cup, were not included in this series.

SURGICAL TECHNIC

The surgical technic of these operative cases varies over the 16-year period covered in this survey. The cases in which operation was performed between 1940 and 1950 followed closely the classic method described by Smith-Petersen. However, beginning about 1950, this group of orthopaedists began to modify the procedure in several respects. First, they began to use the posterolateral approach to the hip joint. Through this approach they found that they were better able to dislocate the hip quickly with less loss of blood and without having to remove as much of the acetabular rim, if any.

Through this posterior incision it was found to be extremely helpful to remove the tip of the greater trochanter with the abductor muscles. This was done in all cases except 2 in this series operated upon since 1950. It became apparent to us, as we did more arthroplasties through this posterolateral approach, that previously we had paid too little attention to the normal mechanics of the hip joint. Before 1950 we had sacrificed a great deal of bone over the head of the femur and almost routinely had taken all the cartilage and the subchondral bone out of the acetabulum. This, we have found, further shortened the already inadequate lever arm of the abductor muscles. In most cases of degenerative arthritis the lever arm is so shortened as a result of wear of the acetabular cartilage and the cartilage on the head that the hip is decompensated from a mechanical standpoint. Therefore, we made it a point to try to circumvent this by re-attaching the trochanter downward on the femur a sufficient amount to re-establish normal lever-arm relationship for the abductor muscles. Sometimes this required transplantation of the trochanter downward as much as 1 inch from its excised position.

As more cases were done utilizing this method, we found that it was not necessary to remove large amounts of bone from the acetabulum and the head of the femur. In fact, the review seems to indicate that the best results were obtained in those cases in which the least amount of bone was removed It occurred to us that it was unnecessary to drill out the cartilage from the acetabulum unless the acetabulum definitely needed deepening. Only in those cases in which the acetabulum is poorly developed,

or is posed at an oblique angle, is it necessary to deepen the acetabulum; nor is it necessary to shorten the length of the head and the neck. The head can be made smaller by reducing its size circumferentially without reducing its length. Thus, it will accommodate an adequate cup and have sufficient room for freedom of motion. By transplanting the trochanter downward, more normal tension is maintained on the abductor muscles, and instability and dislocations are prevented postoperatively. The only postoperative dislocation in this group of arthroplasties occurred in a case in which the trochanter was pulled out as the result of a fall 2 weeks after surgery.

We have found that the rehabilitation of the abductor muscles has come about more quickly in those cases in which the trochanter was transplanted downward to establish a more normal abductor muscle-acetabular relationship.

About 1950 we began removing more and more of the capsule of the hip joint instead of trying to resuture it after the arthroplasty. This procedure was predicated on the idea that most of the pain-bearing fibers of the hip joint have their origin in the hip-joint capsule and the synovial membrane. We consider this concept to be practical in view of the fact that it has not been definitely established exactly what role endosteal bone pain plays in the pain of osteoarthritis. Therefore, we feel that we are removing the vast majority of pain-bearing fibers of the hip joint by taking out the entire capsule. In most degenerative arthritic hip joints the hip-joint capsule is so fibrotic and thickened and avascular that it is a limiting factor in itself in regard to motion of the hip, and probably restricts circulation. We do not consider it a necessary anatomic structure for stability of the hip joint in preventing dislocations. Since 1950, in 95 per cent of the arthroplasties done by this group, the capsule was removed as completely as possible.

Another problem that has seemed to be a great stumbling block to the function of many arthroplasty operations was the amount of new bone formation that occurred. Since about 1950 we have used increasing amounts of oxidized cellulose gauze in and round the base of the nck, under the cup and in any other points at which there is exposed bone. It is our impression that it may be helpful in preventing large amounts of new bone formation. No proved bad effects have been observed.

Frequently in bilateral cases it is difficult to determine on which hip to operate first. It has been our plan to decide on the hip that has been the more painful. By operating on the more painful hip we found that many of the bilateral cases got along well for years because of the improved function and relief of pain in the hip that underwent surgery so that it was unnecessary to operate on the opposite side. Forty-one of the 101 cases operated upon had bilateral hip-joint disease.

Since 1950 we have modified our postoperative care in these arthroplasty cases. Many of the earlier cases were placed in plaster with traction straps inside the cast and left in plaster for a period of 2 or 3 weeks, or even longer. Since 1950 the majority of cases have been started on early active exercises as soon as pain would permit. We have also used an arthroplasty type of splint on a board with rollers on the splint to allow for abduction and flexion exercises aided by passive motion of the joint through pulleys and ropes. Early ambulation is the rule so long as there is a good hip on the other side to enable the patient to use crutches. Weight-bearing on the side operated upon is started as early as 6 weeks in some cases. Since we have not removed so much of the subchondral bone from the head and out of the acetabulum, we have started weight-bearing as soon as the abductor muscles permitted or at the time the transplanted trochanter appeared by roentgenogram to be firmly united.

TABLE 2. POSTOPERATIVE COMPLICATIONS

	PATIENTS
Massive new bone formation requiring removal of cut and prosthesis..	2
Deep infection requiring removal of the cup	2
Infection requiring drainage	5
Temporary foot drop due to peroneal nerve paralysis	3
Thrombophlebitis	2
Fatal pulmonary embolus..........	1
Nonfatal pulmonary emboli........	3
Marked absorption of the neck requiring removal of cut and prosthesis..	2
Dislocation into secondary acetabulum	1
Dislocation following avulsion of transplanted trochanter	1

POSTOPERATIVE COMPLICATIONS

The postoperative complications are tabulated in Table 2. In this series they have not been numerous. Four of the earlier cases developed such massive new bone formation round the cup which restricted motion to such a degree that the cup had to be removed. In 1 case there was a serious deep-wound infection that made it necessary to remove the cup.

Of the 108 hips operated upon in this series, only 2 became dislocated. One of these occurred in the group operated upon before 1950 and the other in the group after 1950. The earlier case occurred in a patient who had had a congenital dislocation and a secondary acetabulum had formed above the normal site. At the time of the operation an attempt was made to deepen the original acetabulum to hold the cup in the newly formed socket. The cup, however, dislocated postoperatively into the secondary acetabulum, but the end-result was good from the standpoint of pain and range of motion. The stability of the hip still was poor, and the patient continued to have an abductor limp.

The other case of dislocation occurred in a patient in whom the trochanter had pulled loose from its transplanted position. The hip was manipulated into place, and the trochanter was replaced in the transplanted position with another screw. The hip did not dislocate again, and the end-result was good.

There was a total of 4 postoperative deep infections which required drainage. One hip had a chronic recurrent drainage for as long as 5 years, with an ultimate good result.

Another postoperative complication was temporary peroneal paralysis with foot drop, which developed in 3 cases. The paralysis in these 3 cases indicated that the probable cause was pressure over the peroneal nerve as a result of the arthroplasty splint during the first few days postoperatively while the patient was heavily sedated. Eventually all made a full recovery.

Two patients developed a thrombophlebitis with prolonged excessive swelling of the entire extremity. One patient died of a pulmonary embolus the day that he returned home 4 weeks after operation. Two cases of pulmonary emboli were not fatal.

Marked absorption of head and neck under the cup occurred in 2 cases to such a

TABLE 3. ADDITIONAL PROCEDURES

	PATIENTS
Excision of capsule	84
Acetabulum deepened or trimmed ...	10
Trochanters transplanted	82
Removal of the cup (usually a Whitman reconstruction or prosthetic replacement was done.*)	9
Obturator neurectomies	9
Adductor tenotomies	29
Postoperative manipulations	5
Shelving procedures	1
Section lateral cutaneous nerve of thigh	1
Replacement of the cup with prosthesis*	2
Neurectomy of sciatic branch of the hip joint	1
Reattachment of avulsed trochanter..	1
Lengthened iliopsoas	2

* When this was done the case was classed as a failure of arthroplasty.

marked degree that the cups were removed and prosthetic replacements were inserted.

Four patients of the selected group for this end-result study were known to be dead as a result of carcinoma or other causes not related to the operation at the time this review was done.

ADDITIONAL PROCEDURES

The additional procedures are tabulated in Table 3. In 84 of the 108 hip joints operated upon the capsule was removed as completely as possible (77%). We have estimated that we were able to excise 90 per cent of the capsule and the synovium. In 67 of the 108 cases (62%) the acetabulum was remolded in some form or other. Either the edges were trimmed or the acetabulum was definitely reamed out to remove the roughened cartilage. In some cases it actually was deepened where needed. In 29 per cent the subchondral bone actually was cut through.

Several other additional procedures were done, either at the time of the arthoplasty operation or as a secondary procedure. Eight cases included in this group of additional procedures are those considered to be failures because the cup was removed for one reason or another. Usually a Whitman reconstruction or a prosthetic replacement was done after the cup was removed.

Obturator neurectomies were performed upon 9 patients for relief of adductor spasm and pain distribution over the obturator nerve. The adductor tendons were tenotomized in 29 cases.

Postoperative manipulations were carried out under anesthesia in 5 cases. These manipulations were done because of a deforming flexion and/or adduction contracture in the early stages of healing. It appears that this procedure has no lasting effect. Most of these cases requiring manipulation of any kind ended up as failures.

A shelving procedure was done in 1 case because of a grossly inadequate acetabular roof. The result in this case was poor.

The lateral cutaneous nerve of the thigh was sectioned in 1 case because of persistent radiating pain over that nerve's distribution. A section of the nerve to the posterior hip-joint capsule from the sciatic nerve was done in 1 case because of persistent pain over that distribution.

METHOD OF FOLLOW-UP STUDY

As part of the follow-up study in these 101 patients, a questionnaire was sent to each. The questions included were intended to elicit the feelings of the patient about the operation. While questionnaires sent to the patient are helpful in deciding the end-result in a particular case, the conclusions cannot be exact. Results that are established on the basis of answers to questionnaires alone are often erroneous. For example, a patient with a completely stiff hip following an arthroplasty may be almost symptom free so far as pain is concerned and yet may be totally satisfied with the result. Furthermore, the answers received to questionnaires often had to be corrected and modified at the time the patient was interviewed because they did not reveal the true symptomatic picture of the patient.

Each patient then was given an orthopaedic examination for this end-result study. The examiners noted particularly the following findings:

1. Walking ability
2. The degree of internal rotation
3. Hip flexion
4. The degree of external rotation
5. The degree of extension
6. Degree of abduction
7. Each patient was tested to determine whether or not he had a positive or a negative Trendelenburg test.

A method of classifying the results according to subjective complaints and objective findings was worked out for each classification. Table 4 shows the criteria by which each case was classified.

In order to qualify as an excellent result, the patient's subjective complaints should

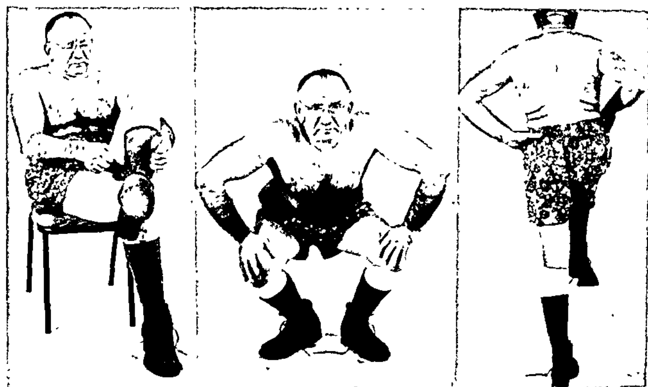


FIG. 1. (*Left*) A 62-year-old man who walked with crutches before surgery and had been unable to tie his own shoe for over 10 years. He now can run up and down stairs without the use of a hand rail and is pain free. Had 40° fixed flexion deformity of left hip preoperatively. (*Center*) Ability to flex and abduct left hip is quite adequate for most functions (*Right*) The left hip is stable 4 years after operation, and the patient walks with practically no limp.

TABLE 4. CLASSIFICATION OF RESULTS

SUBJECTIVE COMPLAINTS	OBJECTIVE FINDINGS
Excellent:	
No pain	No limp
No restriction of motion	Passive and active motions as good as opposite hip
Patient feels the operated hip is as good as opposite hip	
Good:	
Minimal or no pain	Negative Trendelenburg test
Walks with slight or no limp	Flexes hip at least to 90°
Does not require crutches or cane	Abducts at least 25°
Puts on own shoes and stockings	Sufficient internal and external rotation to allow patient to put on shoes and stockings
Able to pursue a gainful occupation if employed before surgery—or does own housework	
Fair:	
Some pain but much improved over presurgical condition	Moderate limp
	Able to flex hip 60°
Improved ability to walk	Abduct 15°
May use cane but not crutches	Flexion deformity of 30° allowed
Poor:	
More pain and restricted motion than before surgery	Definite decreased range of motion
	Decreased ability to walk

FIG. 2. (*Top, left*) A young man 30 years of age with an ankylosing spondylitis and complete ankylosis of hips in this position (about 135°). He was severely handicapped and walked in this position. (*Top, right*) After bilateral cup arthroplasty 4 years previously patient walks quite well without cane or crutches in this position. While not a good result from standpoint of bilateral arthroplasty, patient is greatly improved and very satisfied. (*Bottom, left*) Bilateral ankylosing arthritis with Marie-Strumpell spine. Hips fixed in 135° flexion. Quite marked atrophy of bone of head and neck. (*Bottom, right*) Four years postoperatively bone has held up quite well, although there has been some shortening of neck. Hips are practically painless, but motion is only fair.



reveal no pain and no restriction of motion, and he should feel that the hip which underwent operation is as good as the opposite, or normal, hip. His objective findings should show that he has no limp, that passive and active motions are as good as a normal hip.

To classify as a good result, subjectively the patient has minimal or no pain, he walks with slight or no limp, does *not require* the use of crutches or cane, is able to put on his own shoes and stockings, and is able to pursue a gainful occupation if employed before surgery or, in the case of a woman, is able to do her own housework. Objectively, *the* patient has a negative Trendelenburg test, flexes his hip at least to 90° *and abducts to* at least 25°. (See Fig. 1.)

In the group classified as fair, the subjective complaints included some pain, but it was much improved over what it was before surgery; the patients walked better, and they were allowed to use a cane but not crutches.

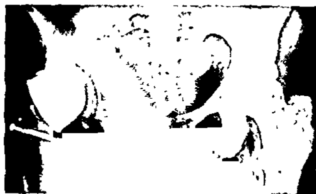


FIG. 3. The transplanted trochanter helps to maintain a more nearly normal abductor muscle acetabular relationship. The problem of new bone formation round the cup is a difficult one to overcome.

Objectively they had moderate limps but were able to flex their hip to 60° and abduct to 15°. A flexion deformity of 30° was allowed.

The poor results subjectively showed more pain and restricted motion than before surgery. Objective findings verified the subjective complaints, with definite decrease in range of motion and ability to walk.

The classification of end-results in arthroplasties of the hip is rather complicated because of the many factors involved in each case. A subjective evaluation of the case alone, from questionnaires and interrogation of the patient, often is misleading. In most instances, the patient up-grades the result, while the surgeon is disappointed in it. For example, a result may be regarded as quite successful by the patient with an ankylosing spondylitis and bilateral hip joint ankylosis but as a rather poor result by the surgeon in a bilateral osteoarthritic case. (See Fig. 2.)

For this reason it was decided that to qualify for this end-result study, each patient was required (1) to have undergone operation at least 1½ years previously; (2) to answer detailed questions about his subjective symptoms, both by questionnaire by mail and by interrogation at the time of examination; (3) to have a complete orthopaedic examination within the past 2 years; and (4) to have roentgenograms of the hip taken if there had been none in the past 2 years.

As a result of these requirements, many of our cases were thrown out because they could not be located or failed to meet one of the other requirements. We were able to accumulate 101 patients who had undergone 108 cup arthroplasties and met these qualifying requirements.

The final estimate of these cases, recorded in Table 5, was arrived at by setting a standard for the subjective and the objective findings in each case and classifying it as excellent, good, fair, or poor. It will be noted that only 6 cases were classified as excellent, and it must be emphasized that these were unusually good results. Those cases classified as good numbered 43. Thirty-six cases were classified as fair, and it should be noted that a fair result was one that was completely satisfactory from both the patient's and the surgeon's point of view. The poor cases numbered 7 and included those in which the patient was neither improved in walking ability nor relieved of pain. Of the 8 cases classed as failures, the cups were removed for one reason or another. Of these complete failures, it is interesting to note that 3 cases were in the group of old suppurative arthritis of the hip and 2 were fracture dislocations of the hip. One was a case of rheumatoid arthritis with a spondylitis, and 2 cases were from the group of degenerative arthritis without specific cause. Three patients included in the group are known to

TABLE 5. END-RESULTS OF 108 CUP ARTHROPLASTIES DONE ON 101 PATIENTS

	No. Cases	
Excellent	6	5.7
Good	43	42.5
Fair	36	36.7
Poor	7	6.8
Complete failures	9	8.8
Total	101	

have died from other causes not related to the operation but were qualified to be included in this study.

In conclusion, evaluation of end-results on 101 patients indicates that a satisfactory result can be obtained in approximately 85 per cent of the cases selected for this particular procedure. The operation should be reserved for those people who are having increasing, progressive hip-joint pain.

Our attitude may change regarding the indication, so far as older people are concerned, in that the use of a prosthesis may be the easiest and quickest method of obtaining a pain-free movable hip in a person who has a short life expectancy. However, for the most part, it appears that we should not throw away viable bone of neck and head in order to replace it with a metal prosthesis. The end-results of the Vitallium cup arthroplasty are sufficiently satisfactory for its continued use. If failure occurs, usually sufficient viable bone is left for the insertion of a prosthesis.

Studio del Resultatos Definitive in Arthroplastias Coxal a Cuppa de Vitallium

Summario in Interlingua

Dr. med. Harry E. Emmel, Dr. med. John F. LeCocq, Dr. med. Edward A. LeCocq, Dr. med. Darrell G. Leavitt, Dr. med. Harry L. Leavitt, Dr. med. Kirk J. Anderson, Dr. med. Henry H. Nash, e Dr. med. J. Garth Mooney presenta un serie de 108 arthroplastias a cuppa de Vitallium executate in 101 patientes in le curso de un periodo de 16 annos. Le duration medie del symptomas esseva 8, 7 annos e del observationes postoperatori 3, 9 annos. Le etates del patientes variava inter 16 e 72 annos. Septanta-duo del patientes habeva inter 30 e 70 annos de etate, e 65 esseva masculos.

Le indication pro le intervention chirurgic esseva arthritis septic in 8 casos, dislocation congenite in 8 casos (incluse 4 bilateral), coxa var luxante in 6 casos (incluse 3 bilateral), arthrocatadysis in 2 casos, morbo de Perthes in 2 casos, arthritis rheumatoide in 12 casos (incluse 6 bilateral), dislocation per fractura in 5 casos, necrosis aseptic in 2 casos, e osteoarthritis in 55 casos. Isto representa un serie total de 101 casos que esseva omnes usabile in le presente studio de resultatos definitive.

Le technica chirurgic sequeva fidelmente le methodo classic de Smith-Petersen in 28 operationes executate inter 1940 e 1950. Post 1950 le technica esseva modificate in multe respectos. Le posterolateral via de approche esseva utilisate con ablation del trochanter major, sequite per re-insertion del trochanter a sito abassate pro restaurar le mechanica levatori del musculos de abduction. Per contrasto con le practica anterior, nulle amontas major de cartilagine e de osso esseva dismontate ab le capite del femore e ab le acetabulo. Grados maximal de capsulectomia e synovectomia esseva practicate in consequentia del argumento que isto resulta in le elimination del plus grande portion del afferente fibras nervose que transmitte le dolores e assi in un melioration del grado de motilitate. Gaza de cellulosa oxydate esseva utilisate pro restringer le neoformation de osso. Quanto al bandage, le spica gypsate esseva abandonate in favor de un apparato arthroplastic a rotellos. Motion passive esseva initiate tanto tosto como le dolores lo permitteva. Portage de peso al latere operate esseva initiate in certe casos post un intervallo postoperatori de non plus que sex septimanas.

Le complicationes postoperatori non esseva numerose. Dislocation postoperatori occurreva in 2 casos; massive neoformation de osso in 2 casos; infection con necessitate

de drainage in 5 casos; transiente paralyse de nervo peroneal in 3 casos; thrombophlebitis in 2 casos; embolo pulmonar in 3 casos (incluse 1 mortal); e absorption marcate del capite e cervice del femore in 2 casos. Octo nonsuccessos in le serie total pertineva a iste categoria de complicationes imponente le necessitate de remover le cuppas de Vitallium.

Manovras additional effectuate al tempore del *operation initial esseva tenotomia de* adductor e refraction de rebordos. Chirurgia secundari esseva requirite in le forma de neurectomia obturatori o sciatic in 9 casos, de manipulation in 5 casos, de elimination del cuppa de Vitallium (con secundari operationes de Whitman o reimplaciamentos prosthetic) in 9 casos, section del lateral nervo cutanee del femore in 1 caso, e reattachamento del avellite trochanter major in 1 caso.

Le classification del ultime resultatos esseva effectuate super le base del constatationes objective e etiam del gravamines subjective del patientes in un total de 101 casos. Le casos classificate como excellente esseva *inusualmente bon. Iste classe includeva 6* casos (5,7%). Pro esser admittite a iste classe, le coxa debeva esser libere de dolores e capace de motion in un maniera comparabile a un coxa normal sin ulle tracia de claudication. Le numero del bon resultatos *esseva 43 (42,5%). Patientes in iste gruppo* habeva pauc o nulle dolor, leve grados de claudication que non requireva crucias o cannas, un negative signo de Trendelenburg, e leve grados de restriction del motion in le articulation coxal. Le numero del casos classificate como satis bon esseva 36 (36,7%). Iste patientes se plangeva de un certe grado de dolor; illes usave un canna; e objectivemente illes monstrava un grado moderate de claudication. Flexion esseva effectuabile usque a 60° e abduction usque a 15°. Un deformitate flexional de 30° esseva permittite. Le resultatos pauco satisfacente monstrava plus dolor e minus motilitate que ante le operation. Lor numero esseva 7 (8,1%). Le serie includeva 9 malsuccessos absolute (8,8%). Tres patientes includite in iste gruppo moriva ab causas sin relation al operation. Illes esseva prendite in consideration in le evalutation del resultatos final.

Le autores opina que le resultatos obtenite esseva generalmente satisfactori ab le puncto de vista del chirurgo e ab le puncto de vista del patiente in 84 pro cento del casos seligite pro iste operation.

7

Fractures of the Hip in the Aged and Disabled: A Study of the Relation of Preoperative Evaluation and Preparation to Morbidity and Mortality

LEWIS M. OVERTON, M.D.*

The purpose of this study has not been to evaluate end-results of hip fractures but, rather, to study the problems encountered in elderly and chronically ill patients with fractured hips. The study does not include any individuals under 70 years of age except those in whom the fracture was complicated by severe chronic illness or other factors that would be expected to increase materially the morbidity and the mortality.

The literature is relatively replete with studies on morbidity and mortality as related to pre-existing disease in persons with fractures of the hip. There are a few studies on mortality rate in the aged with hip fractures; however, these do not include morbidity. Boyd and Griffin[1] reported 360 cases with an over-all mortality of 7 per cent. There was 1 death under 70 years of age. Van-Demark and VanDemark[6] reported 104 patients 80 years of age and older with a mortality of 12½ per cent. The deaths are analyzed, but nothing is reported on the over-all morbidity. This same group[7] later reported another group with a mortality of over 14 per cent. Koons[4] reported 300 cases with a mortality of 16 per cent. These were not separated as to age. Other authors[2,3,5] have stressed the importance of preoperative evaluation of these patients. However, none of them presented their morbidity studies.

Most elderly and chronically ill persons drink and eat sparingly. As a result, many of them are in a continued state of mild dehydration and dietary deficiency. When injured, they will be more likely to exhibit some degree of shock with very early, subsequent evidence of electrolyte imbalance. This will be more significant in the presence of a chronic debilitating disease. If the trauma of surgery is superimposed on that of the fracture in these persons without first correcting the imbalance, the postoperative course will be much stormier, and both the morbidity and the mortality will be increased. Decrease of these complications will require a careful preoperative evaluation of each individual, followed by supportive therapy to reduce the complications to a minimum. A reasonable length of time is required to accomplish this end, which presupposes that these fractures cannot be treated as emergencies.

* Section of Orthopedic Surgery, Lovelace Clinic, Albuquerque, New Mexico.

TABLE 1. PREOPERATIVE COMPLICATING FACTORS (53 PATIENTS, 56 HIPS)

COMPLICATING FACTORS	AGE GROUPS (Years)					TOTAL
	50-59	60-69	70-79	80-89	90 and Over	
Average for age			11	2	1	14
Advanced cardiovascular Disease :						
Rheumatoid heart disease				1		1
Myocardial infarct	1	1	3	4	1	10
Cerebrovascular accident	1		2	4		7
Cerebral arteriosclerosis		1	3	1		5
Arteriosclerosis with hypertension		2 (3 hips)	1	5		8 (9 hips)
Arteriosclerosis without hypertension				2		2
Malignancy			2			2
Severe rheumatoid arthritis with osteoporosis		2 (3 hips)				2 (3 hips)
Rheumatoid arthritis Pulmonary tuberculosis, fat emboli	1					1
Severe injuries, shock		1 (2 hips)				1 (2 hips)
Total	3	7 (10 hips)	22	19	2	53 (56 hips)

We became quite interested in this problem, and for the last 10 years it has been our policy to place the elderly patient with a fracture of the hip in traction upon admission to the hospital. The internist examines the patient carefully and then makes an evaluation of his general condition. Supportive therapy is given as indicated Surgery on the hip is not performed until the condition of the patient has improved to the extent that the least possible strain will be placed on the person

Fifty-seven patients with 60 fractures of the hip were selected for the study. All patients over 70 years of age have been included and only those under 70 in whom the fracture was complicated by a serious preexisting factor. All others were excluded because they did not fall within the scope of this study. Incidentally, no deaths occurred in the excluded group. Fifty-three of the patients with 56 fractures were treated by surgery. Of the 4 not operated upon, 1 was in a terminal state of cardiac decompensation and died within 12 hours, 2 were 92 years of age and had suffered complete hemiplegias from previous cerebrovascular accidents, and the fourth was in the advanced stages of malignancy with multiple metastases.

The 53 patients treated surgically were analyzed on the basis of their physical con-

dition at the time of admission to the hospital, as shown in Table 1. It will be noted that the health of only 14 was considered to be average for their age. Cardiovascular disease was by far the most frequent complicating factor encountered in the group. There were 33 cases (62.2%) in which the cardiovascular disease was severe enough to be a serious factor in the prognosis. There were 2 cases of malignancy, one of which had sustained a pathologic fracture. The single case of rheumatoid arthritis and pulmonary tuberculosis probably would not have been included had the patient not developed multiple fat emboli 20 hours after the injury. This necessitated a delay of 39 days before surgery.

From 24 to 48 hours was required to evaluate the patients; therefore, no operations were performed earlier than 24 hours after admission to the hospital. All who did not have severe complicating factors were operated upon within 3 days. There were 41 in this group (Table 2). Operation was deferred 4 days or longer in 5 patients who developed preoperative complications. One developed a moderate upper respiratory infection, 2 developed abdominal distentions due to ileus, and 1 developed fat emboli. In all the others, the delay was due to the preexisting complicating factors. However, there is no doubt that the shock of trauma aggravated these conditions to a varying degree.

TABLE 2. TIME LAPSE BETWEEN INJURY AND SURGERY (56 HIPS)

INTERVAL IN DAYS	NUMBER
1	8
2	22
3	11
4	5
5	10

The immediate preoperative preparation for surgery included light sedation so as to produce the minimal depression. The type of anesthesia selected by the anesthesiologist was the one best suited to the patient's condition. The only exception to this policy was in those patients in whom it was felt that another type of anesthesia would not increase the surgical risk.

General anesthesia was employed 27 times; spinal, 17 times; local, 7 times; and a combination of local and general, 5 times. The type of anesthesia did not influence the postoperative course, except that it was felt that it was a little more difficult for those who had received a general anesthetic to ambulate early.

All patients were ambulated within 48 hours and over 60 per cent within 24 hours after surgery. The average period of hospitalization after surgery was 17.8 days, the shortest being 4 days and the longest 48 days. Thirty-one (55.5%) remained in the hospital less than 14 days, 11 (19.5%)

TABLE 3. POSTOPERATIVE HOSPITALIZATION PERIOD WITH COMPLICATIONS

DURATION (Days)	NUMBER OF HIPS	COMPLICATIONS	DEATHS
Less than 14 days	31 (55.5%)	3*	2 (3.78% for patients, 3.57% for hips)
14-21 days	11 (19.5%)	2	
Over 21 days	14 (25%)	3	
Average: 17.8 days			

* Includes two deaths.

remained from 14 to 21 days and 14 (25%) remained over 21 days. There was no significant relation between the lengths of postoperative hospitalization and postoperative complications (Table 3).

The 2 fatal complications were in the group with the shortest hospitalization. There was also 1 mild postoperative upper respiratory infection. There were 2 complications in the second group. One of these had some mental disturbance prior to surgery, but this became exacerbated for a few days following surgery, and the other was a patient with a pathologic fracture whose recovery was extremely slow. Of the 3 complications in the group with a hospital stay of over 21 days, 2 were patients in their late eighties who became mentally confused. This cleared slowly. The other patient developed a pulmonary embolus 48 hours after surgery. This was the only patient in whom the delay in surgery was a probable factor in the complications. The patient developed a severe ileus and required a delay of 7 days before surgery. The extended hospitalization of the remainder in this group was due either to inadequate facilities for care at home or to long distances of travel to their homes.

There were 2 deaths in the group. One occurred in an 86-year-old man whose general health was considered to be average for his age. Surgery was performed within 48 hours after the injury, and the patient was up in a wheel chair the day after surgery He developed a massive pulmonary embolus 4 days postoperatively. The second death occurred in an 89-year-old man who had been in a mental institution for 2 years because of advanced cerebral arteriosclerosis with some dementia. This was accompanied by moderate cardiac insufficiency. The patient did well after surgery except for slight mental confusion. Then, on the early morning of the sixth postoperative day, he suffered a cerebrovascular accident. This was followed by unconsciousness and death the following day.

SUMMARY AND CONCLUSIONS

The most important first consideration in each elderly patient with a fracture of the hip is not the fracture but, rather, the patient as a whole. What is the general physical and mental condition of the patient? This must be determined and evaluated; then the complicating factors must be corrected in so far as possible prior to surgery if postoperative complications are to be avoided and the mortality reduced to the lowest reasonable percentage.

The delay in surgery for a period of time sufficient to evaluate and prepare the patient adequately for operation will lower rather than increase the complications In our study there was only 1 patient in whom the delay in surgery could have been a factor in the postoperative complication. He developed a severe ileus which it took a week to correct and also a nonlethal pulmonary embolus 48 hours after surgery. The 1 preoperative death could not have been considered suitable for surgery in any circumstances because that patient was in a terminal status at the time that she was first examined.

The average postoperative hospitalization was 17.8 days, 55 per cent of which was less than 14 days. Of those who remained over 21 days, there were extenuating circumstances in all except 3 cases. The reason for the longer stay for uncomplicated cases was either a lack of adequate facilities at home for their care or the long distances of travel to their homes. The mortality rate of 3.78 per cent for the number of patients and 3.57 per cent for the number of hips operated, when compared with other studies, would suggest that careful attention to the general status of the patient prior to surgery is of definite significance, in that it resulted in a substantial lowering of both the morbidity and the mortality rates.

REFERENCES

1. Boyd, H. B., and Griffin, J. L.: Fractures of the hip: results following treatment, J.A.M.A. 137:1196-1199, 1948.

2. Cleveland, M., and Fiedling, J. W.: Continuing end results study of intracapsular fractures of the neck of the femur, J. Bone & Joint Surg. 36A:1020-1030, 1954.
3. Edwards, W. C.: Fractures of the hip of elderly patients, J.A.M.A. 157:1635, 1955.
4. Koons, R.: Anesthetic management of the aged for fractured hip surgery, Geriatrics 10:225-228, 1955.
5. Rowe, C. W., and Detwiler, R. C.: Fractures in the aged, J.A.M.A. 162:1517-1522, 1956.
6. VanDemark, G. E., and VanDemark, R. E.: Hip nailing in patients eighty years or older, Am. J. Surg. 85:664-668, 1953.
7. VanDemark, G. E., VanDemark, R. E., and VanDemark, W. E.: Hip nailing in the tenth decade, Geriatrics 10:418-420, 1955.

Fracturas del Coxa in Personas de Etate Avantiate e in Invalidos: Un Studio del Relation inter (1) Evalutation e Preparation Preoperatori e (2) Morbiditate e Mortalitate

Summario in Interlingua

Le studio es concernite con le problemas incontrate in individuos de etate avantiate o con maladias chronic quando illes suffre fracturas coxal. Le studio non se concerne con le resultatos final que es attingite per le coxas fracturate per se.

Es presentate 53 patientes, omnes suffrente de sever, avantiate, e chronic morbos que complicava le fractura coxal. Le methodos appropriate al tractamento de iste problemas es presentate, e le importantia del meticulose evalutation e preparation preoperatori del patiente es sublineate. Datos relative al morbiditate e mortalitate postoperatori es presentate, e le essayo es facite de evalutar le complicationes incontrate.

Le resultatos del studio indica que il es importantissime dedicar un evalutation meticulose a omne patiente individual qui suffre de un fractura coxal, con le objectivo de corriger le factores complicatori in tanto que possibile ante le effectuation del operation chirurgic.

8

Rupture of Tendons of the Biceps Brachii

A Case Report

SPENCER T. SNEDECOR, M.D.*

In working men between the ages of 50 and 70 rupture of the tendon of the biceps brachii is not an uncommon happening. Perhaps the incidence is increasing, for in our own practice we have seen 17 instances in the past 4 years and have operated upon 11, yet relatively little has been written about this entity in recent literature. Fourteen of our cases happened in workmen's compensation practice. We have not seen a case in a woman.

In most instances the diagnosis was not made early, and surgical intervention thereby was delayed. One patient recognized the situation himself and came to us because he had injured his opposite arm in a similar fashion 2 years before. He never had received treatment for what had since proved to be a serious handicap. Actually, the diagnosis is not difficult, and once seen it is quite characteristic. A working man just beyond middle age complains that while lifting he suddenly felt something snap in his arm and that this was followed by local pain which was not too severe. Then he notices some weakness in his arm, but does not identify this too accurately because he is still able to flex and use the elbow with the aid of the brachialis anticus and the accessory muscles On examination, the typical appearance shown in Figure 1 reveals the biceps to be visible in a contracted mass distal to its normal position. If acute, it will be slightly tender. The flexion strength of the elbow is weakened. In only 2 instances have we observed a complete rupture of the distal tendon, and in those cases the biceps "lump" was proximal to its normal position.

The mechanism of the injury usually is a lifting strain with the elbow flexed. Perhaps it is a sudden strain, but rarely beyond the individual's usual capacity. For example, one man who ruptured both biceps at the same time described his injury as occurring when he lifted a heavy pipe above the horizontal with both arms.

PATHOLOGY

The pathology is somewhat variable as to the location of the rupture, but always it is based upon a degenerative process in the tendon that has been developing over a considerable period. In each instance we have been impressed by the yellowish frayed appearance of the tendon ends, even in the recent cases. The underlying chronic degenerative lesion which predisposes to the tears is seen in Figure 2. In most cases the long tendon of the biceps was ruptured close to its junction with the muscle. One case was torn so close that there was hardly enough tendon base to hold the repair su-

* Hackensack, N. J.

tures. Another case ruptured midway in its length, and 3 ruptured at its insertion on the glenoid margin. The man with the bilateral rupture first came to us 3 months after injury and delayed surgery. At 6 months he came back and requested surgery for the right arm. He felt that he would accept the disability in his left arm because of the postoperative helplessness of doing both at once. Only 4 cases ruptured distally. Two tore right off completely at the radial tubercle, and both of these also tore across the bicipital aponeurosis, or lacertus fibrosus. One tendon tore two thirds of the way through close to the bicipital tubercle. The fourth patient, who suffered a partial tear which was not operated upon, had considerable disability and lost time from work for 3 months. In retrospect, surgery probably would have helped this case.

If a period of time elapsed before surgery, invariably the tendon retracted and frequently coiled up (Fig. 3), encasing itself in a thin mesenchymatous sac containing serous fluid. The muscle belly always was found to be contracted and fixed in proportion to the lapse of time between the rupture and the surgical repair. Yet, even the case 6 months' old could be stretched out satisfactorily by blunt dissection and traction.



Fig. 1. Typical swelling of contracted biceps mass after rupture of tendon.

OPERATIVE TECHNIC

As a result of our studies on the first 2 or 3 cases, we developed an operative technic which has proved to be simple and satisfactory. For the upper tendons, a 4- to 5-inch anterior skin incision beginning below the acromion extends obliquely along the inner border of the biceps. The tendon in its encapsulated sac is identified quickly and then is used for traction to restore the length of the muscle. Usually, blunt dissection is required to mobilize the muscle, depending



Fig. 2 Chronic degenerative changes in biceps tendon at site of rupture.

on the duration of the injury. In the cases of long standing, the muscle must be followed well distal to free it sufficiently to stretch it out to full length. It requires care to identify and preserve the musculocutaneous nerve supply and the blood vessels coming in from the brachial group. The *short head of the biceps is easily demonstrated.*

Our fixation technic has consisted essentially of a tenodesis of the tendon origin close to the muscle into the bicipital groove as far proximally as it can be stretched. The bicipital groove is prepared by carefully scraping and roughening. After the most proximal point of fixation is demonstrated by flexing the elbow and pulling the muscle upward, the arm again is extended, 2 drill holes are made into the bicipital groove, and a double wire suture is carried through them. The elbow again is flexed and held so throughout the remainder of the operation. The double-wire suture is divided, *each is woven through the tendon at the* proximal end of the muscle, and both are tied firmly so that the muscle now will obtain its origin from the bicipital groove. Any extra tendon proximal to the sutures is excised and discarded, and the wound is closed in the usual manner. The aftercare consists of splinting the arm at 90° of flexion for 3 weeks. Then follows a week in a sling

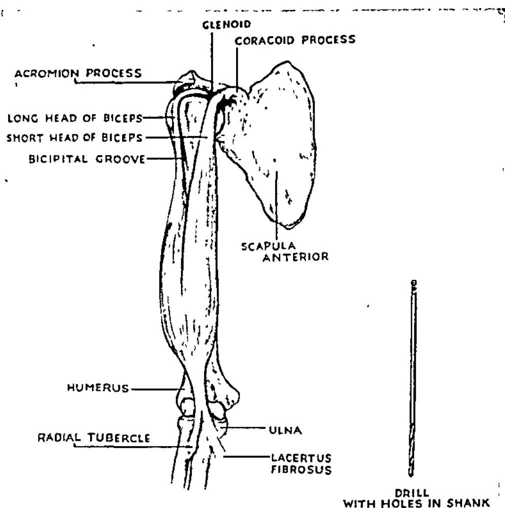


FIG. 3. Anatomy of the biceps brachii.

with gentle, active exercise. After 4 weeks a gradually increasing program of active exercise is given; full use after 6 weeks.

The cases of rupture of the distal tendon were found to be more of a problem because that tendon goes into a deep tunnel in the antecubital fossa to reach its insertion on the radial tubercle. An anterior bayonet-design incision is made across the elbow joint. The ruptured tendon is easily identified, but it is not always easy to suture it back to its original attachment on the bicipital tubercle. A special drill, as shown in Figure 4, is a big help. By beveling off the shank and punching 2 holes through, the surgeon can thread the drill point as a needle with a pull-out wire. After he has drilled through the bone, he can remove the drill handle, thread the drill point with wire (which has been woven through the end of the tendon) and push it out through the dorsum of the forearm. The wires can be hooked around from the dorsal aspect of the radius and sutured back again through the distal end of the tendon, or they can be pulled out through the dorsum of the forearm and tied over a button. In the latter instance a pull-out wire should be looped through this retaining suture in the tendon before it is fixed and led out through the skin anteriorly. After 4 weeks the button is cut off and the pull-out wire will remove both sutures. In the distal tendon cases we have delayed active motion 2 more weeks because the tendon does not come in contact with as much bone surface. If this anatomic repair cannot be made, then a simple splice of the radial end of the tendon to the lacertus fibrosus on the ulna side will function well. Although this loses the supination action of the radial insertion, it does restore the flexor strength of the elbow, and, interestingly enough, our 1 case had good supination. This verified our war experience, when we found that the radial tubercle insertion was not essential to good function. One surgeon has recommended that the insertion be made into the brachialis muscle as close as possible to its attachment to the coronoid process of the ulna. This would have exactly the same result as reattaching it to the ulna fascia. The 1 case of partial rupture near the bicipital tubercle was repaired successfully with a wire pull-out suture tied over a button on the dorsum of the forearm.



FIG. 4. Typical rupture of long tendon, which had coiled up.

CONCLUSIONS

We have found that rupture of the proximal long tendon and also the distal tendon of the biceps brachii is not uncommon, particularly in industrial practice.

A degenerative process in either tendon of this muscle in men from 50 to 70 predisposes to the injury.

Once the clinical entity comes into focus, the diagnosis is relatively easy.

A satisfactory operative technic has been described.

Our operative results have been routinely good. In each instance the men returned to their previous occupations, and they have been able to do such heavy work as shoveling coal.

BIBLIOGRAPHY

Burnham, P. J.: Repair of the avulsed distal biceps tendon, Rocky Mountain M. J. 49: 838-840, 1952.

Conwell, H. E., and Alldredge, R. H.: Ruptures and tears of muscles and tendons, Am. J. Surg. 35:22-33, 1937.

Dobbie, R. P.: Avulsion of the lower biceps brachii tendon. Analysis of fifty-one previously unreported cases. Am. J. Surg. 51:662-683, 1941.

Gilcreest, E. L.: The common syndrome of rupture dislocation and elongation of the long head of the biceps brachii, Surg., Gynec. & Obst. 58:322-339, 1934.

Goldenberg, R. R.: Avulsion of the distal biceps brachii tendon, J. M. Soc. New Jersey 47: 114-115, 1950.

Haldeman, K. O, and Soto-Hall, R.: Injuries to muscles and tendons, J.A.M.A. 101:2319-2324, 1935.

Hølund, T.: Rupture and hernia of the tibialis anterior muscle, J. Bone & Joint Surg. 34A: 678-679, 1952.

Hook, F. R., and Mazet, R., Jr.: Avulsion of the biceps tendon from its radial insertion, U. S. Naval M. Bull. 40:409-411, 1942.

Lieberman, H. S.: Traumatic subluxation of the long head of the biceps brachii, J. Bone & Joint Surg. 22:425-428, 1940.

Long, L.: Bilateral independent rupture of the long head division of the biceps brachii, Am J. Surg. 51:684-688, 1941.

Rankin, J. O.: Rupture of the long head of the biceps brachii, J. Bone & Joint Surg. 15: 1003-1006, 1933.

Ratzan, M. C.: Spontaneous rupture of the biceps tendon (long head), Indust. Med 22: 360-361, 1953.

Schlossbach, T.: Avulsion of the lower biceps brachii tendon, J. M. Soc. New Jersey 47: 166-167, 1950.

Sharpe, W. E., Jr.: Avulsion of the distal tendon of the biceps brachii, Am. J. Surg. 54:733-736, 1941.

Simon, H. E.: Muscle hernia: with report of six additional cases in the arm and leg, Mil Surgeon 97:369-374, 1945.

Tarsy, J. M.: Bicipital syndromes and their treatment, New York J. Med. 46:996-1001, 1946.

Thiemeyer, J. S, Jr.: Disinsertion of the biceps brachii, U. S. Armed Forces M. J. 1:543-545, 1950.

Section II

GENERAL ORTHOPAEDICS

9

Slipped Capital Femoral Epiphysis*

William J. Schnute, M.D.†

Within recent years the subject of slipped capital femoral epiphysis has been presented repeatedly in the literature and at orthopaedic meetings. It is interesting to note how varied the treatment of this condition can be, and yet satisfactory results with each method of treatment used are reported by many authors. The methods include manipulation, osteoplasty, osteotomy of the neck of the femur, subtrochanteric osteotomy, and replacement of the slipped head of the femur at the epiphyseal line. It is hard to conceive that all these methods of treatment will give equally good results when the problem involves a deformity of a major weight-bearing joint during the adolescent period. This diversity of opinion among skilled orthopaedic surgeons can only mean that no one method of treatment, thus far at least, has stood out as being the most satisfactory for this condition.

This chapter deals with a consecutive series of 16 patients with 21 hips that suffered slipping of the capital femoral epiphysis and underwent operation by the author since 1943 following the method that he had been taught and that had been used previously at the University of Michigan Hospital by Dr. Carl E. Badgley. Each case is reported in as much detail as is available, and every effort has been made to obtain as long a follow-up in each case as was possible, including examination and roentgenograms. In two of the cases all roentgenograms have been discarded, and in several others some of the pertinent roentgenograms have been lost. Some of these cases have been reported previously by the author's partner Dr. Clinton L. Compere, but in the interim the follow-up studies of these cases have yielded further information regarding the behavior of the head of the femur with continued use.

The cases presented have all been treated by internal fixation and include those pinned *in situ*, where the degree of displacement was minimal, as well as those that underwent an open reduction with replacement of the head of the femur in a corrected position.

When open reduction of the hip has been used, exposure has been made through an anterolateral Smith-Petersen approach. Adequate exposure is always necessary to permit the surgeon maximum freedom in the hip joint. This point has been emphasized repeatedly by other authors.

The skin incision is made in a gentle curve, extending from a point about 3 inches posterior to the anterosuperior iliac spine, crossing it anteriorly about 1 inch below, and then proceeding distally an additional 4 inches below it. The resulting scar from this incision avoids bony prominences. The proximal portion of the incision is carried

* From the D[illegible] Northwestern U[illegible] Wesley Memori[illegible] dale Sanitarium [illegible]

† Associate Professor, Department of Orthopaedic Surgery, Northwestern University Medical School, Chicago, Ill.

down to the anterior crest of the ilium, where by means of an osteotome the lateral one third to one half of the crest of the ilium is osteotomized outward in order to enter the subperiosteal space about ½ inch below the crest of the ilium. This variation from the original Smith-Petersen approach permits reattachment of the tensor fascia femoris and portion of the gluteus medius with greater security than is possible when only the muscle edges are available for resuturing. A moist laparotomy pack over a blunt instrument completes the subperiosteal dissection of the gluteus muscles down to the superior portion of the acetabulum. The pack is left in place to protect the reflected portion of bone and muscle while the distal arm of the incision is opened.

Immediately below the anterosuperior iliac spine, the interval between the sartorius muscle medially and the tensor fascia femoris laterally is identified and separated. A perforating vessel is found constantly immediately distal to the anterosuperior iliac spine, and this should be ligated on exposure. The sartorius muscle is reflected medially; the tensor fascia femoris is reflected laterally. The rectus femoris muscle lying beneath the sartorius is also reflected medially. Directly underneath the rectus femoris muscle, at a point approximately 3 inches distal to the anterosuperior iliac spine, the femoral circumflex vessels are found constantly. Before they have been torn or cut, they should be isolated, clamped and doubly ligated to avoid unnecessary bleeding. *It is very difficult to control hemostasis from these vessels if inadvertently they have been cut before being clamped.* The lateral femoral circumflex vessels and the previously mentioned superficial iliac circumflex vessels are the only ones of importance encountered in this approach, and identifying and clamping these vessels permits a bloodless approach to the hip joint.

The exposure then continues along the lateral edge of the rectus femoris muscle, and the reflected head of the rectus femoris muscle is identified and freed carefully by blunt dissection. *The reflected head of the rectus femoris muscle must be sectioned as it passes over the capsule of the hip joint,* but, as a rule, the direct head of the rectus femoris muscle need not be sectioned and can be adequately retracted laterally. At this point the anterior and superior capsule of the hip joint is exposed completely. The capsule of the hip joint is opened carefully by incising the capsule obliquely in the direction of the fibers, with a cross incision along the margin of the acetabulum and also at the base of the capsule near the intertrochanteric line.

Immediately upon opening the capsule of the hip joint, usually it is noted that the articulating portion of the head of the femur is not visible, and in its place the periosteum is seen to cover the denuded portion of the metaphysis of the femoral neck. This periosteum is incised sharply in the direction of the neck of the femur along the metaphysis to the margin of the articulating cartilage if it can be seen. Cross incisions also are made above and below to permit gentle reflection of flaps of the anterior periosteum. Marked external rotation of the hip at this point usually exposes the margin of the articulating portion of the head of the femur. Occasionally, however, the slip of the femoral epiphysis posteriorly and inferiorly has been so great that even now it may not be visualized. If the edge of the cartilage-covered surface can possibly be seen, a curved blunt osteotome is used to probe gently beneath the articulating cartilage for the epiphyseal plate. This should be done by hand control rather than by using a mallet.

Great care is needed to dissect carefully the head of the femur at the epiphyseal plate. This procedure is tedious and requires great patience and skill on the part of the operator. When the head is being separated from the neck, every effort should be made not to tear the posterior capsule still attached to the head of the femur for maximum preservation of any blood supply en-

tering the head of the femur through the posterior capsule.

After the head of the femur has been separated carefully from the neck and is completely free, a wedge of bone is taken from the metaphyseal portion of the neck of the femur. *The base of the wedge is directed superiorly and anteriorly to permit replacement of the head gently and without stretching the posterior capsule,* and also to place the head in a valgus position on the neck of the femur with central placement in the lateral projection. *Experience has shown that for the head of the femur to be placed centrally in regard to the lateral position there is an apparent overhang of the edge of the head of the femur which may be as much as 1 cm. from the edge of the femoral head to the neck of the femur.* After the positioning of the femoral head has been completed, internal fixation to maintain position during the healing phase is carried out.

Several means have been used for placing the pins or wires, but it is the author's practice at present to use a separate lateral incision about 3 inches long below the greater trochanter to expose the lateral portion of the upper shaft of the femur and directly insert the wires. This offers several advantages, in that the wires can be placed more accurately; and, since it is also the author's plan to remove routinely the wires at a later date, an incision at this point is necessarily required when they are removed. This has proved to be much more satisfactory than earlier attempts at placing the wires directly through the skin without incision or by extending the inferior arm of the Smith-Petersen incision laterally and posterially at the point of insertion of the tensor fascia femoris with the tensor fascia lata.

Several kinds of internal fixation have been used. The Smith-Petersen nail has been used, but the head of the femur is found to be very hard, and considerable force is needed to drive it into the head of the femur. Threaded wires have been used, but, if the smaller gauge threaded wire is used, it is difficult to control it at times. The author feels that heavy-gauge threaded wires, or perhaps screws, are more satisfactory.

The head of the femur should be located centrally in relation to the neck of the femur on the lateral roentgenogram, but definitely the line of osteotomy and the position of the head of the femur should be in a valgus position, permitting constant impaction at the osteotomy site and ensuring rapid healing and a vascularization of the head of the femur as rapidly as possible. This observation agrees with the concepts of Dr. Robert T. McElvenny on the necessity of obtaining this position in the treatment of fresh intracapsular fractures of the hip joint.

Complications from this surgery are not related to the incision in any degree but are completely dependent upon the work done within the hip joint itself. The chief complication is that of aseptic necrosis of the head of the femur. The danger points which may cause this complication can be prevented by the gentle handling of the tissue, including the periosteum, where it is incised and reflected anteriorly and superiorly, by gauging accurately the amount of stretch that is placed on the posterior periosteum and by avoiding the tearing of the posterior periosteum, either by the instruments used in the dissection of the head or by the forceful replacement and stretching of the head onto the neck of the femur. A second point at which a complication may easily develop is that of transecting the head of the femur itself. This may happen if a sharp instrument is used to explore the epiphyseal plate, particularly with a mallet. This may also develop if more than one operator does this step and the "feel" of the epiphyseal plate plane is lost. This may also happen if there is partial bony healing posteriorly and inferiorly, necessitating the use of a sharp instrument and a mallet.

To complete the surgical procedure, the incision is closed anatomically in layers, and a compression dressing is applied.

Postoperative care has consisted of the use of Russell's traction for a varying period of

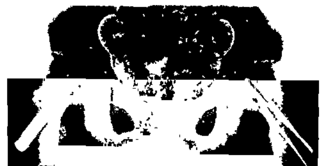


FIG. 1. Case 1. January 28, 1946. Roentgenogram showing bilateral slipped capital femoral epiphysis.

time, from 3 or 4 days to 2 or 3 weeks, or until the hip passively could be moved freely. The patient then has been encouraged to ambulate with crutches, the affected leg not bearing weight. Full weight-bearing has been permitted only when there has been roentgenographic evidence of union of the head of the femur with the femoral neck, and also when there are no residual symptoms of soreness or stiffness about the hip joint.

CASE REPORTS

Case 1. An 11½-year-old boy with a symptom of a mild limp for about 1 year's duration. At that time no definite diagnosis was made, and he was not seen again for 2 years, when he had a history of increasing limp and pain in both hips. The diagnosis was bilateral slipped capital femoral epiphysis (Fig. 1). The boy weighed 115½ pounds, but there was no evidence of endocrine disturbance. Open reduction of both hips was carried out. The right hip was operated upon by another surgeon, a Smith-Petersen nail being used for fixation. Multiple threaded wires were placed in the left hip by the author (Fig. 2). The wires were removed 15 months later, when the patient had no symptoms referable to either hip and no limp, and there was essentially normal motion in both hips.



Case 2. A 14½-year-old boy at the time of original consultation with symptoms of pain in the left knee and hip, limitation of motion of the hip and a hip limp on the left following a fall from a bicycle 1 year previously. This boy was obese. On examination he walked with a definite hip limp on the left; the left lower extremity was held in external rotation. There was limitation of the extremes of flexion and abduction of the left hip. A diagnosis was made clinically and by roentgenogram of a slipped capital femoral epiphysis on the left.

Open reduction of the left hip was carried out with internal fixation by means of multiple threaded wires. The wire fixation, however, was not felt to be too stable. Because of this, a spica cast was applied and left on for 4 weeks, after *which the patient walked with crutches.* At time of his discharge his hip was asymptomatic. Unfortunately, all roentgenograms on this case have been discarded.

Case 3. A 17-year-old boy with symptoms referable to the right hip for about 1 year. He recalled no specific injury, although there was some question of his having hurt his hip in sliding into base while playing baseball at the time his symptoms began. On examination this boy

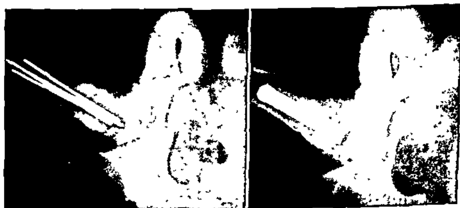


FIG. 2. Case 1. February 3, 1947. Roentgenograms showing open reduction, both hips with internal fixation — Smith-Petersen *nail, right hip,* threaded wires, left hip.

weighed 140 pounds and was 6 feet tall. He did have a definite endocrine disturbance with an additional diagnosis of gynecomastia. The right lower extremity was 1 inch shorter than the left; there was no internal rotation of the right hip; external rotation contracture was present; abduction was to neutral; flexion, 30°. A diagnosis was made of slipped capital femoral epiphysis on the right.

An open reduction was carried out on the right hip with internal fixation by 4 threaded wires. This boy did well following surgery. He moved to another city, and reports during the next year indicated that he continued to do very well. Unfortunately, original roentgenograms were discarded.

Case 4. A 12-year-old girl. When first seen in November, 1946, there was a history of pain and limp referred to the left hip of 4 weeks' duration. Symptoms became acute 3 days before admission following a ballet lesson. Examination at that time revealed a complete restriction of motion in all directions of the left hip.

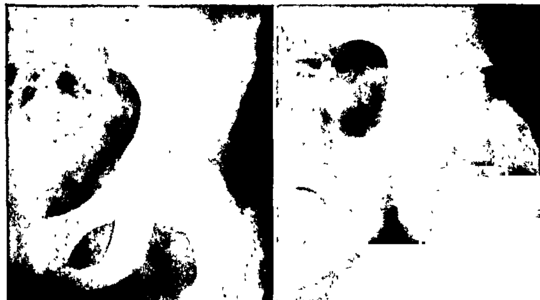


FIG. 3. Case 4. December 16, 1946. Slipped capital femoral epiphysis, left hip.

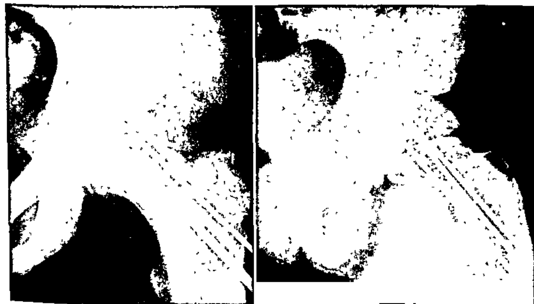


FIG. 4. Case 4. December 19, 1946. Open reduction and internal fixation with multiple threaded wires, left hip.

The patient was unable to bear weight on the left leg. This girl was small and thin but had been in good health. The left lower extremity was placed in traction for 2 weeks (Fig. 3). At the end of that time an open reduction was carried out with internal fixation by multiple threaded wires (Fig. 4).

By 1951 the subject was a student nurse, and at that time there was a normal range of motion of the left hip in all directions. There was only ¼-inch shortening of the left lower extremity (Fig. 5).

A letter received from this patient on April 22, 1957, stated that she had married recently and was expecting a baby in July. Because of this, we could not obtain roentgenograms for this chapter. She wrote: "There has been no hip disturbance, and I am unaware of the surgery that I had 12 years ago I have full motion of the hip, and it has not prevented me from any activity that I wished to engage in."

Case 5. An 11½-year-old girl with onset of symptoms 3 months before consultation following a fall. Two weeks later she had another fall from a bicycle, followed by immediate pain



Fig. 5. Case 4. December 28, 1951. Five years after open reduction and threaded wire fixation—normal range of motion.



Fig. 6. Case 5. December 28, 1946. Original roentgenograms showing slipped capital femoral epiphysis, left hip Acute displacement.

about the left hip. These symptoms increased slowly. One week before admission she slipped on an icy sidewalk with marked increase of pain in the left hip and was then unable to bear weight on the left lower extremity. On examination (December 28, 1946) there was complete restriction of motion in all directions of the left hip with marked pain on any attempted motion. The hip rested in a marked external rotation position. A diagnosis was made clinically and by roentgenogram of an acute slipping of the left capital femoral epiphysis (Fig. 6). Russell's traction was applied with gradual, complete correction of the deformity by roentgenogram. On January 7, 1947, internal fixation of the left hip was carried out with multiple threaded wires without opening the hip joint, anteroposterior and lateral x-ray control being employed. Crutches were used for 3 months. On July 15, 1947, the threaded wires were removed from the left hip, at which time the motion of the left hip was normal.

On June 2, 1957, the subject entered a convent and now is teaching fourth-grade grammar school in Cincinnati, Ohio. She was referred to Dr. Joseph Freiberg for examination, and roentgenograms were taken of her pelvis. Dr. Freiberg wrote: "This patient has had no difficulties whatsoever associated with her left hip. For the past number of years she has engaged in sports and other normal activities. On examination, though rather large and heavy, she had no limp. There were bilateral negative Trendelenburgs. Hips recumbent showed approximately equal degree of abduction bilaterally. With both hips extended there was no measurable limitation of rotation in the left or the right hip. Flexed at 90° the left hip had approximately 25° of limitation of internal and external rotation as compared with the right. Motion in both hips

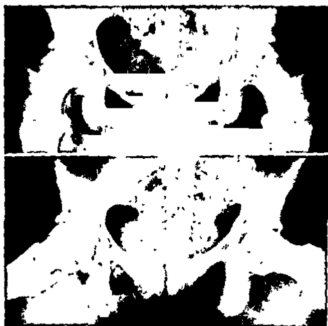


Fig. 7. Case 5. May 31, 1957. Ten years after operation—left hip entirely asymptomatic on all normal activities. Slight limitation of internal and external rotation with left hip flexed as compared with the right.

was from 45° to 180° without symptoms. Length of both legs equal." (Fig. 7)

Case 6. A 13½-year-old boy with onset of symptoms 1 month prior to consultation with gradually increasing limp and soreness about the left hip and immediately above the left knee. There was no preceding injury or illness. Examination (June 9, 1948) revealed a tall obese boy, who walked with a marked limp and had limitation of internal rotation and limitation of the extreme of flexion of the left hip. He walked with the left lower extremity in an externally



Fig. 8. Case 6 June 9, 1948. Original roentgenograms showing a marked slip of the capital femoral epiphysis, left hip. (Compere, C. L.: J. Bone & Joint Surg. 32A:358)

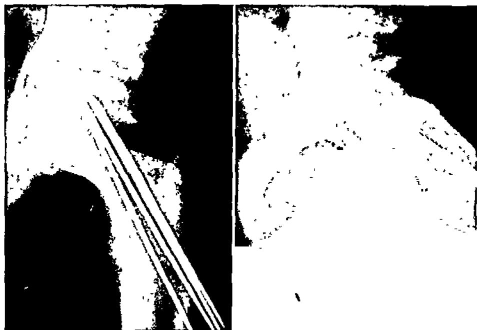


FIG 9. Case 6. August 3, 1948. Six weeks after open reduction and internal fixation with multiple threaded wires, showing superior third of head not in contact with femoral neck because of necessity of obtaining desired position.

rotated position. Clinically and by roentgenogram there was evidence of a marked degree of slipping of the capital femoral epiphysis on the left (FIG. 8).

On June 21, 1948, open reduction of the left hip with complete freeing of the capital femoral epiphysis and replacement in a satisfactory position was followed by internal fixation with multiple threaded wires. In order to obtain the desired position, the superior third of the head was not in contact with the femoral neck (Fig. 9). In spite of the defect between the superior surface of the neck and the head of the femur, this area filled rapidly with bone. On December 3, 1948, the threaded wires were removed. On January 18, 1949, the use of crutches was discontinued, and a normal range of motion of the left hip in all directions was noted. There was only ½-inch shortening of the left lower extremity. On August 30, 1956, the patient was entirely asymptomatic and was pursuing normal activities. Examination revealed a normal range of motion of the left hip in all directions (Fig. 10).

Case 7. A 13½-year-old girl with onset of symptoms 3 months prior to examination, at which time she fell while skating and injured her right hip. She was able to walk home but, because of pain and stiffness of the right hip, was in bed for 1 month and then became ambulatory with crutches. Examination (April 20, 1950) revealed a very definite hip limp with marked limitation of motion of the right hip. She was slender in build, weight, 86 pounds. Examination of the



FIG. 10. Case 6. August 30, 1956. Eight years and 3 months after operation. Left hip entirely asymptomatic on normal activities with normal motion.



FIG. 11. Case 7. April 15, 1950. Original roentgenograms showing slipped capital femoral epiphysis, right hip.

right hip revealed it to be held in marked external rotation. There was 3 cm. of true leg shortening; 10° of hip flexion was possible; there was no abduction and no internal rotation (Fig. 11).

On April 28, 1950, an open reduction of the right hip was carried out with internal fixation by multiple threaded wires (Fig. 12). By May 17, 1950, she was ambulatory with crutches. On September 23, 1950, the threaded wires were removed, and the patient became ambulatory with full weight-bearing on the right hip. When examined on July 18, 1957, she had been working regularly and at no time had had any difficulty regarding the right hip. No symptoms were noted with weather changes or excessive fatigue. On examination the patient walked without a limp; there was a negative Trendelenburg bilaterally; the right lower extremity was ⅜ inch shorter than the left. The right hip had a range of motion equal to that of the uninvolved normal left hip (Fig. 13).

Case 8. A 13½-year-old boy with onset of symptoms of pain in both hips about 6 months prior to first examination. There was no preceding injury or illness. Examination (December 2, 1951) showed limitation of internal rotation and flexion of both hips. Diagnosis was made of a minimal slipping of the capital femoral epiphysis, bilateral (Fig. 14).

On December 3, 1951, internal fixation of the right hip was done without changing the position



FIG. 12. Case 7. July 27, 1950. Three months after open reduction and threaded wire fixation.

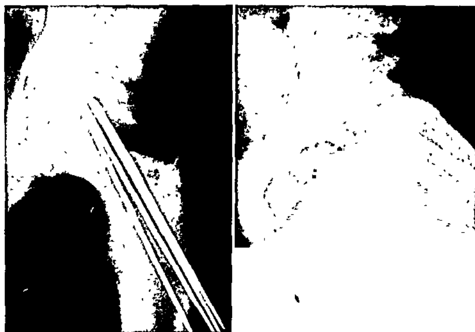


FIG. 9. Case 6. August 3, 1948. Six weeks after open reduction and internal fixation with multiple threaded wires, showing superior third of head not in contact with femoral neck because of necessity of obtaining desired position.

rotated position. Clinically and by roentgenogram there was evidence of a marked degree of slipping of the capital femoral epiphysis on the left (Fig. 8).

On June 21, 1948, open reduction of the left hip with complete freeing of the capital femoral epiphysis and replacement in a satisfactory position was followed by internal fixation with multiple threaded wires. In order to obtain the desired position, the superior third of the head was not in contact with the femoral neck (Fig 9). In spite of the defect between the superior surface of the neck and the head of the femur, this area filled rapidly with bone. On December 3, 1948, the threaded wires were removed. On January 18, 1949, the use of crutches was discontinued, and a normal range of motion of the left hip in all directions was noted. There was only ½-inch shortening of the left lower extremity. On August 30, 1956, the patient was entirely asymptomatic and was pursuing normal activities. Examination revealed a normal range of motion of the left hip in all directions (Fig. 10).

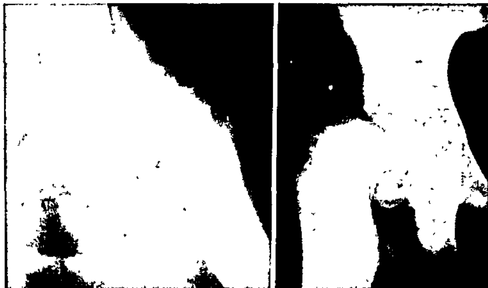
Case 7. A 13½-year-old girl with onset of symptoms 3 months prior to examination, at which time she fell while skating and injured her right hip. She was able to walk home but, because of pain and stiffness of the right hip, was [illegible]

tation of motion of the right hip. She was slender in build; weight, 86 pounds Examination of the



FIG. 10. Case 6. August 30, 1956. Eight years and 3 months after operation. Left hip entirely asymptomatic on normal activities with normal motion.

Fig. 11. Case 7. April 15, 1950. Original roentgenograms showing slipped capital femoral epiphysis, right hip.



right hip revealed it to be held in marked external rotation. There was 3 cm. of true leg shortening; 10° of hip flexion was possible; there was no abduction and no internal rotation (Fig. 11).

On April 28, 1950, an open reduction of the right hip was carried out with internal fixation by multiple threaded wires (Fig. 12). By May 17, 1950, she was ambulatory with crutches. On September 23, 1950, the threaded wires were removed, and the patient became ambulatory with full weight-bearing on the right hip. When examined on July 18, 1957, she had been working regularly and at no time had had any difficulty regarding the right hip. No symptoms were noted with weather changes or excessive fatigue. On examination the patient walked without a limp; there was a negative Trendelenburg bilaterally; the right lower extremity was ⅜ inch shorter than the left. The right hip had a range of motion equal to that of the uninvolved normal left hip (Fig. 13).

Case 8. A 13½-year-old boy with onset of symptoms of pain in both hips about 6 months prior to first examination. There was no preceding injury or illness. Examination (December 2, 1951) showed limitation of internal rotation and flexion of both hips. Diagnosis was made of a minimal slipping of the capital femoral epiphysis, bilateral (Fig. 14).

On December 3, 1951, internal fixation of the right hip was done without changing the position



Fig. 12. Case 7. July 27, 1950. Three months after open reduction and threaded wire fixation.





Fig. 13. Case 7. July 15, 1957. Seven years and 3 months after operation. Right hip entirely asymptomatic.

of the femoral head. On December 10, 1951, internal fixation of the left hip was carried out, again without changing position of the femoral head. By May 3, 1952, crutches were discontinued, and a normal range of motion of both hips in all directions was noted. On December 26, 1952, the threaded wires were removed from both hips, except for 1 pin on each side, which were broken, and could not be removed. On April 20, 1957 (Fig. 15), no discomfort at any time had been noted in either hip in all normal activities, including college gymnastics, wrestling and golf. Examination revealed that there was a slight restriction of internal rotation bilaterally, but all other hip motions were normal.

Case 9. A patient of Dr. Orren Baab, with whom the surgery was performed. This 16½-year-old boy had an onset of symptoms about 6 months before first being seen, when he fell



Fig. 14. Case 8. November 20, 1951. Bilateral minimally slipped capital femoral epiphysis. Note the importance of lateral views in making an x-ray diagnosis. Both hips pinned *in situ.*



Fig. 15. Case 8 April 20, 1957. Five and one half years after operation. Broken piece of threaded wire remaining on each side.

while tumbling in school. He had pain in the left hip and the left knee. At the time of the first examination (October 25, 1953) a marked limp was noted on the left, the left leg being held in external rotation. No internal rotation or abduction at the hip was possible. A diagnosis, clinically and by roentgenogram, was made of a slipped capital femoral epiphysis on the left. On October 26, 1953, open reduction of the left hip and internal fixation with multiple threaded wires was carried out. On November 2, 1953, the patient began to use crutches. When last seen in April, 1954, he had a complete range of motion of the left hip in all directions and was asymptomatic (Fig. 16).

Case 10. A 12½-year-old boy with symptoms of pain, stiffness of the left hip and limp for 3 months following a fall while playing basketball. The symptoms of pain, stiffness and limp of the left hip increased in severity. On examination (July 16, 1954) there was marked limitation of internal rotation, abduction and flexion motions of the left hip. Diagnosis was made clinically and by roentgenogram of a slipped capital femoral epiphysis on the left. Unfortunately, the original roentgenograms have been discarded.

On July 19, 1954, an open reduction of the left hip with internal fixation, using multiple threaded wires, was carried out. The right hip was pinned *in situ* at the same time. On January 28, 1955, all wires were removed (Fig. 17). Patient was asymptomatic.

Case 11. A 15-year-old boy whose symptoms began about 4 months prior to the first examination with pain in his left hip following a twisting injury to his hip in getting out of a boat. Pain in the hip and limp on the left continued. Two months later the family physician was consulted, and roentgenograms of the hips were reported to be normal. The patient went out for football practice and after 3 days had to stop because of



Fig. 16. Case 9. April 22, 1954. Six months following open reduction and internal fixation, showing solid healing of epiphyseal plate and osteotomy site.

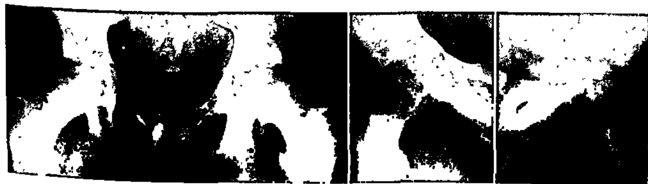


Fig 17. Case 10. February 1, 1955. Postoperative roentgenograms showing fusion of both epiphyseal plates following open reduction of the left hip and pinning of the right hip *in situ* 7 months previously

discontinued. The hip then was entirely asymptomatic, and the range of motion was normal. On January 1, 1956, the left hip continued to be entirely normal after return to normal activities. However, during the previous 4 weeks the patient had noted pain in the *right* hip, aggravated by fatigue, stair climbing or extremes of motion. Examination revealed a limp on the right, limitation of internal rotation of the right hip, and pain on forced internal rotation (Fig. 19). On January 23, 1956, insertion of multiple threaded wires into the right hip was carried out without changing the position of the femoral head. On April 17, 1956, the threaded wires were removed from the right hip. On May 28, 1956, the use of crutches was discontinued. On March 19, 1957, both hips were noted to be entirely asymptomatic; the patient had a normal gait and a normal range of motion in all directions of both hips. He had been playing football on a Military Academy team, and at the present time was trying out for the track team in pole-vaulting, which he had done prior to his original hip difficulty (Fig. 20).

Case 12. A 9-year-old girl. On September 7, 1954, the patient fell, injuring her left hip. The following day she fell again, had severe pain in the left hip and was unable to walk. A diagnosis of a slipped capital femoral epiphysis was made by the family physician. The left hip was manipulated and immobilized in a 1½ spica cast. Roentgenograms in the cast showed no change in position of the femoral head. The cast was removed, and manipulation was carried out a second time, followed by application of bilateral long leg casts that held the legs in abduction and internal rotation (Fig. 21). Following the first examination by the author on November 5,



Fig. 21. Case 12. November 6, 1954. Acute injury to left hip 2 months previously. Two manipulations under anesthesia followed by casts. Acute slipped capital femoral epiphysis on the left. Treated now by open reduction and threaded-wire fixation.

1954, the abduction casts were removed, and the patient was placed in Russell's traction.

On November 8, 1954, an open reduction of the left hip was carried out with replacement of the capital femoral epiphysis in corrected position, the position being held with internal fixation by multiple threaded wires. On January 17, 1955, the left hip was asymptomatic, the patient was still on crutches and non-weight-bearing, and there was a normal range of motion of the left hip. However, a roentgenogram indicated some increased density of the left femoral head. On June 6, 1955, the threaded wires were removed from the left hip, and the child continued on crutches until November 21, 1955. At that time there was a normal range of motion of the left hip in all directions, as well as roentgenographic evidence of complete fusion of the head of the femur and normal vascularization of the head of the femur.

On May 18, 1956, there was an acute onset of



Fig. 22. Case 12. May 23, 1956 Five days following acute onset of pain in right hip. Right leg unable to bear weight.



FIG. 23. Case 12. February 11, 1957. Twenty-seven months after surgery to left hip and 9 months after surgery to right hip. Both hips treated by open reduction and pinning with threaded wires.

pain in the *right* hip with a limp on the right. The right lower extremity was held in marked external rotation. Two days later the patient was unable to bear any weight on the right lower extremity. A diagnosis of an acute slip of the right femoral epiphysis was made. She was hospitalized and traction was applied. The traction was continued for 5 days without appreciable correction (Fig. 22). On May 28, 1956, a manipulation with traction on the operating table failed to give complete correction. Open reduction of the right hip with freeing of the capital femoral epiphysis and replacement in the corrected position was followed by internal fixation with multiple threaded wires. Exposure of the hip revealed that there was a fresh tear of the anterior portion of the periosteum along the anterosuperior lip of the epiphyseal plate with still some recent blood clot remaining where the head had been torn off. On November 19, 1956, the threaded wires were removed from the right hip On February 11, 1957, when crutches were discontinued, the patient walked without a limp, and there was a normal range of motion of both hips in all directions. She was advised to resume all normal activities (Fig. 23).

This case demonstrated potentially serious damage to the blood supply of the head of the left femur. It is the author's impression that the intimate contact of raw bone surfaces with the impaction afforded by the valgus position encouraged a rapid revascularization of the head of the femur, which saved this epiphysis from permanent damage.

Case 13. A patient of Dr. Orren Baab, with whom this patient was operated upon. This 12-year-old girl had an onset of symptoms in the right hip about 1 year prior to examination, with increasing limp and pain in the right knee. This

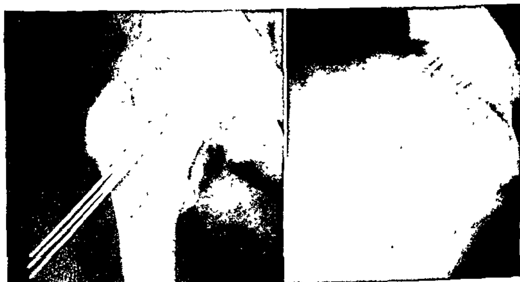


FIG. 24 Case 13. May 24, 1956. One month after open reduction and internal fixation, right hip.



FIG. 25. Case 14. May 8, 1956. Slipped capital femoral epiphysis, left hip. Symptoms of pain in left hip for 1 year.

child was obese and walked with a Trendelenburg gait on the right, maintaining the right lower extremity in marked external rotation. There was limitation of motion in all directions of the right hip with ½-inch atrophy of the right thigh. On April 26, 1956, an open reduction of the right hip with internal fixation, using 3 threaded wires, was carried out (Fig. 24). By June, 1956, there was normal motion of the right hip. On July 19, 1956, partial weight-bearing with crutches was allowed. By August 7, 1956, full weight-bearing was allowed. On February 19, 1957, the threaded wires were removed. On April 2, 1957, the patient was discharged. Range of motion of the right hip in all directions was normal, and she was asymptomatic on all activities.

Case 14. A patient of Dr. William B. Fischer, with whom this patient was operated upon. This 15½-year-old boy had an onset of pain in the left hip about 1 year before the first examination. There was no known injury. Because of continued pain in the left hip, he was seen by the family physician, who recommended crutches, which were used for 2½ months. On original examination (May 8, 1956) this boy was well developed but not abnormally heavy; there was a severe external rotation deformity of the left lower extremity; no abduction was possible; there was free flexion of the left hip; the legs were equal in length (Fig. 25).

On June 1, 1956, an open reduction of the left hip and internal fixation with multiple threaded wires was performed. There was some bony union of the posterior and the inferior portions of the head of the femur, and in dissection of the head of the femur at the epiphyseal plate apparently a false plane was opened and a fracture occurred in the head. The remainder of the head, however, was removed in one piece and replaced in a corrected position. Internal fixation then was done with multiple threaded wires. On September 11, 1956, roentgenograms (Fig. 26) showed the wires to be bent, apparently because of some premature weight-bearing on this hip.



FIG. 26. Case 14. September 11, 1956. Three months after open reduction and internal fixation, left hip. Note evidence of a fracture through the head in the lateral view. The bending of wires suggests premature weight-bearing.

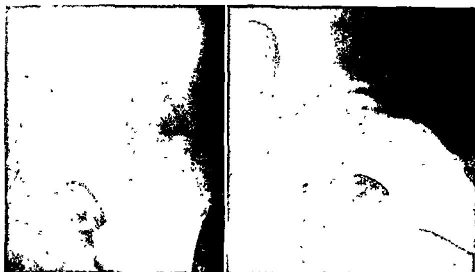


Fig. 27. Case 14. March 22, 1957. Nine months after surgery to left hip. *Evidence of aseptic* necrosis in head fragment.

There was also some restriction of motion of the hip at this time. On March 22, 1957, the wires were removed, there was roentgenographic evidence of vascular disturbance in at least half of the head of the femur, and there was some restriction of hip motion (Fig. 27).

This patient presents the only complication in this series, in that the head of the femur was split at the time of surgery. The author feels that two factors were responsible for this complication: (1) the inferior surface of the capital epiphysis was fused, requiring osteotome section; and (2) the dissection of the epiphyseal plate was shared by two surgeons, which greatly increases the possibility of a false plane being opened Aseptic necrosis of a portion of the femoral head has resulted; consequently the author feels that this boy will not be able to bear weight for a prolonged period and that he will have to use crutches.

Case 15. A 14-year-old boy with onset of symptoms about 1 year prior to examination. Examination (May *29, 1956*) showed marked external rotation deformity of the left hip with limitation of abduction and a limp on the left. Diagnosis was made clinically and by roentgenogram of a slipped capital femoral epiphysis on the left. On May 29, 1956, an open reduction of the left hip was carried out, surgically freeing the femoral head and maintaining the corrected position with multiple threaded wires. By January 9, 1957, the hip was completely comfortable. On examination there was normal range of motion in all directions of the left hip. This boy continued to use crutches, as advised, because of

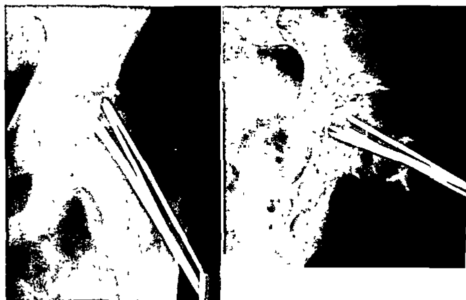


Fig. 28. Case 15. January 9, 1957. Seven and one half months after open reduction and internal fixation, left hip.



FIG. 29. Case 16. October 8, 1956. Slipped capital femoral epiphysis, right hip. Symptoms of pain in right knee following a fall 1 week before. Marked residual paresis and paralysis in right lower extremity following poliomyelitis in 1948.

some delay in complete bony union of the epiphysis with the neck of the femur. It was recommended that he continue to use crutches and have the wires removed in 4 or 5 months (Fig. 28).

Case 16. An 11½-year-old girl. This girl had poliomyelitis in 1948 with residual paresis of both lower extremities, most particularly in the right lower extremity. In 1955 there was 1½-inch shortening of the right lower extremity. On October 4, 1956, she fell from a bicycle, following which she had pain about the right knee. Because of severe pain she began to use crutches. Clinically and by roentgenogram (October 10, 1956) there was found to be a mild slip of the right capital femoral epiphysis. There was an external rotation deformity of the right hip, limitation of complete flexion and abduction, and no internal rotation (Fig. 29). On October 12, 1956, internal fixation of the right hip was carried out with multiple threaded wires without changing position of the right hip (Fig 30). On August 8, 1957, the threaded wires were removed. The right hip was freely movable in all directions, and the child was asymptomatic.

CONCLUSION

A consecutive series of 16 patients with involvement of 21 hips has been reported of slipped capital femoral epiphysis in various stages. One hip was operated upon by another surgeon, who used a Smith-Petersen nail; 3 hips were operated upon jointly with colleagues. In this series of cases only 1 vascular complication has resulted, and the fate of that hip is as yet undecided. This series of cases has been extremely instructive and convinces the author that the treatment of slipped capital femoral epiphysis is a surgical procedure which must be treated at the point of pathology. After noting the condition of the epiphyseal plate at the time of surgery in each case, it seems inconceivable that traction or any manipulation could possibly alter the position of the head of the femur, unless the slip has been acute within a period of 3 or 4 weeks prior to the treatment. The



FIG. 30. Case 16. May 23, 1957. Seven months following pinning *in situ*, right hip.

surgery itself is technically as difficult as, or more difficult than, any other single orthopaedic surgical procedure. End-results of the patients treated by the surgical program outlined indicate that this surgical attack gives the best possible chance of restoring to normal function the hip in which a capital femoral epiphysis has slipped.

It is further suggested that prophylactic pinning of the unaffected hip in cases of unilateral epiphyseal slip is indicated.

BIBLIOGRAPHY

Badgley, C. E., Isaacson, A. S., Wolgamot, J. C., and Miller, J. W.: Operative therapy for slipped upper femoral epiphysis, J. Bone & Joint Surg. 30A:19-28, 1948.

Compere, C. L.: Correction of deformity and prevention of aseptic necrosis in late cases of slipped femoral epiphysis, J. Bone & Joint Surg. 32A:351-360, 1950.

Heyman, C. H., and Herndon, C. H.: Epiphyseodesis for early slipping of the upper femoral epiphysis, J. Bone & Joint Surg. 36A:539-554, 1954.

Heyman, C. H., Herndon, C. H., and Strong, J. M.: Slipped femoral epiphysis with severe displacement, J. Bone & Joint Surg. 39A:293-303, 1957.

Klein, A., Joplin, R. J., Reidy, J. A., and Hanelin, J.: Roentgenographic changes in nailed slipped capital femoral epiphysis, J. Bone & Joint Surg. 31A:1-20, 1949.

———: Slipped capital femoral epiphysis, J. Bone & Joint Surg. 34A:233-238, 1952.

———: Management of the contralateral hip in slipped capital femoral epiphysis, J. Bone & Joint Surg. 35A:81-87, 1953.

McElvenny, R. T.: Personal discussion.

Displaciate Epiphyse Supero-Femoral

Summario in Interlingua

Es presentate un complete revista de vinti-un casos de displaciate epiphyses supero-femoral in dece-sex patientes tractate per le autor. Le indicationes pro intervention chirurgic es discutite e illustrate per referentias al casos presentate. Chirurgia con fixation interne es fortemente recommendate quandocunque le displaciamento del epiphyse supero-femoral es considerabile. In le majoritate del casos, le datos es presentate in lor integritate. Le questiones que pote esser sublevate con respecto al positionamento in le typo de chirurgia usate e con respecto al fixation, al periodo de prohibition de supportar un carga, al rehabilitation, e al resultatos es explicate. In omne casos le presentation del resultatos es extendite usque al tempore presente.

Le objectivo del reporto es exprimer le puncto de vista del autor relative al attacco chirurgic de un problema que per se es capace a resultar in un deformitate permanente del coxa. Il es necessari tentar evitar o corriger ille deformitate le plus promptemente possibile pro restaurar le coxa a un normal functionamento futur. Le technica chirurgic que servi a attinger iste objectivo es difficile e tedie. Illo es cautemente describite. Su execution debe esser maneate con delica tessa si on vole que le resultato es le effectuation de un essentialmente normal articulation coxal.

10

Correction of Paralytic Footdrop by Hemigastrosoleus Transplant

GENE D. CALDWELL, M.D.*

The handicaps produced by paralytic footdrop are well known. The resultant "steppage" gait is unsightly. Control of paralytic footdrop by tendon transplantation to produce active dorsiflexion of the foot is the ideal, but, in the absence of any suitable evertor or invertor muscles for transplantation, some other method must be sought. Arthrodesis of the ankle or posterior ankle block has definite disadvantages that need not be discussed here. A brace, of course, may be used, but with the disadvantages inherent in all braces.

Thirteen patients with paralytic footdrop have been treated by transplanting one half of the gastrosoleus to the dorsum of the foot. With 1 exception, all these patients had no active muscles controlling the foot and the ankle other than a strong gastrosoleus. One patient had an active peroneus longus muscle. A preliminary triple arthrodesis to stabilize the foot was done in all cases. In 1 case the procedure was carried out bilaterally. In 3 cases the lateral half of the gastrosoleus was transplanted through the interosseous space. And in 1 the lateral half was transplanted lateral to the fibula with the peroneus longus to the dorsum of the foot. In 10 cases the medial half of the gastrosoleus was transplanted to the dorsum of the foot by the following technic

* Shreveport, La.

OPERATIVE TECHNIC

The gastrosoleus is exposed through a long posterior mid-line longitudinal incision extending from the mid-portion of the belly of the muscle well down on to the plantar aspect of the heel. The tendon and the aponeurosis are split longitudinally, the division being carried proximally through one half of the muscle belly. The medial half is divided as far distally as possible well down on the heel.

The aponeurotic portion of the gastrosoleus to be transplanted is tubed by a simple continuous suture of No. 000 plain catgut. The middle cuneiform bone on the dorsum of the foot then is exposed through a dorsal longitudinal incision, and a bony trap is fashioned to receive the transplant. A channel for the transplant next is made in the plane between the fat and the deep fascia, the flap being elevated well anteriorly off of the tibia in order that hemigastrosoleus to be transplanted may be transposed anteriorly as far as possible to affect a more direct pull on the dorsum of the foot. This channel is continued downward into the incision on the dorsum of the foot.

The tendon then is drawn through the channel to the dorsum of the foot and implanted into the bony trap previously fashioned. The tendon is sutured directly into

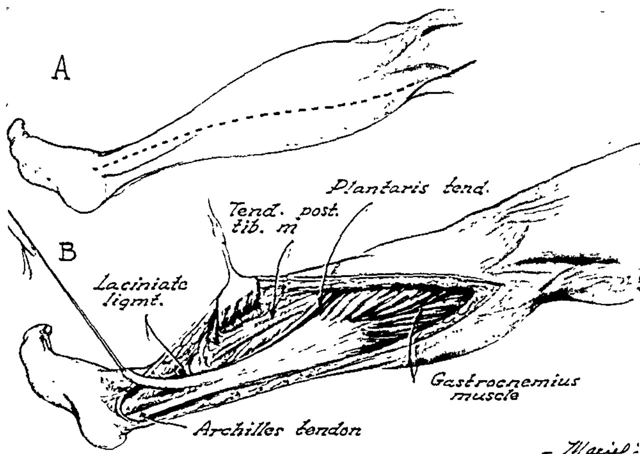


FIG. 1. See text.

bone by any means most suitable with the foot dorsiflexed to from 85° to 80°. If the foot cannot be dorsiflexed with ease to 80° or 85°, the half of the gastrosoleus left intact can be lengthened, although this has not been necessary in any of the cases reported here. The wounds now are closed, and the leg is immobilized in a long leg plaster cast with the foot in maximum dorsiflexion and the knee at 100° of flexion.

AFTERCARE

Immobilization is continuous for 6 weeks, after which the cast is removed and physiotherapy is started. Muscle "re-education" has not been a problem. Ambulation is permitted as soon as the foot drop is demonstrated to be under control either by live tenodesis or by active dorsiflexion of the foot. Ambulation usually is started about 2 weeks after removal of the cast.

RESULTS

Fourteen hemigastrosoleus transplants have been done on 13 patients. The longest follow-up in this series is 3½ years; the shortest, 6 months; with an average follow-up of 22 months.

Of the 4 lateral gastrosoleus transplants, 2 were poor. The gait was improved in these cases; although there was moderate residual footdrop, the transplant acted only as a tenodesis.

One case was rated as good with active dorsiflexion to 90° with the foot drop completely corrected. This was the case, however, in which a peroneus longus of normal strength was transplanted with the lateral gastrosoleus, and in all probability the correction is due largely to the active functioning peroneus longus transplant.

One lateral transplant was a complete failure. This was transplanted through the

interosseous space, and exploration 6 months after operation revealed complete adherence of the transplant throughout its course in the interosseous space.

Ten medial gastrosoleus transplants have been done on 9 patients by the technic just described. In all these cases, footdrop has been controlled effectively by active dorsiflexion to 90° or more by active contraction of the transplanted medial gastrosoleus. Sufficient power to elevate the heel is maintained in the lateral half of the gastrosoleus.

These patients have developed a rocker-type motion of 10° to 20°, and the gait has been markedly improved. Two of these patients have posterior ankle blocks on the opposite side and are much more pleased with the foot in which the transplant has been done.

DISCUSSION

While this series of cases is too small and the period of follow-up observation probably too short to warrant drawing any definite positive conclusions, to date the control of paralytic footdrop by transplanting the medial half of the gastrosoleus to the dorsum of the foot has proved to be most satisfactory. Transplanting the lateral half of the gastrosoleus has been abandoned, since a direct pull cannot be obtained as easily by transplanting round the fibula, and transplanting through the interosseous space is most likely to result in complete adherence

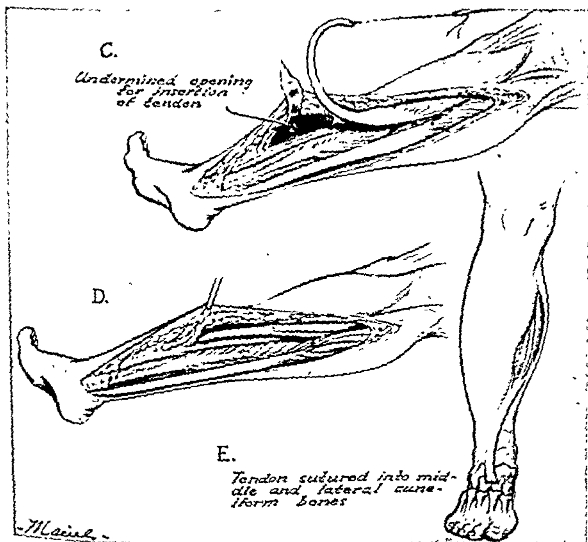


Fig. 2. See text

since the transplanted mass is too large, the space too narrow and the course too long. Transplanting the medial hemigastrosoleus here described affords a fairly direct pull and actually may be called a partial transposition. The neurovascular bundle is too short to permit a complete transposition of the gastrosoleus.

Summario in Interlingua

Un medietate del gastrocnemio e del doleo esseva transplantate al dorso del pede in 14 casos de paralytic pede pendente in le quales nulle altere musculo functionante esseva disponibile pro le transplantation. Iste manovra corrige efficacemente pedes pendente. Le resultatos es multo melior que le resultatos obtenite per blocage talar o arthrodese, proque le motion e le impulso in avante in le ambulation es preservate. Un typo basculante de motion es effectuate, e le ambulation es marcatemente meliorate.

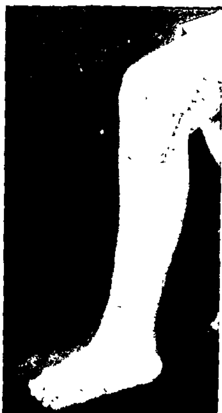


FIG. 3. Range of active motion 2 years after operation.

11

A New Operation for Correction of Cavus Foot*

Fusion of First Metatarsocuneiformnavicular Joints

ROBERT TALBOT MCELVENNY, M.D.†, AND GENE D. CALDWELL, M.D.‡

INTRODUCTION

Cavus foot is corrected permanently by elevating and supinating the first metatarsal bone. Usually, sufficient correction is gained through the first metatarsocuneiform joint. When needed, additional correction and fixation are gained by adding the naviculocuneiform joint to the fusion mass.

One of us (R.T.McE.) first performed the above procedure in 1945. Since that time, our combined series of patients over 7 years of age has shown this procedure to be (1) excellent by itself in dealing with flexible cavus and (2) a valuable adjunct combined with triple arthrodesis when dealing with rigid cavus.

Mid-tarsal section, plantar strippings, plantar neurectomy or common toe extensor tendon transplants have not been necessary.

Occasionally, in marked rigid cavus, a capsulotomy of the great toe joint and fusion of the phalangeal joint and extensor hallucis longus tendon transplant to the first metatarsal head have been done.

At times, phalangeal arthrodesis of a lateral toe or so has been indicated.

Infrequently, subcutaneous section of the plantar fascia has been added.

Cavus deformity is characterized by: (1) a high arch due to forefoot drop and pronation; (2) an *additional* first metatarsal drop below its fellows; (3) tight plantar fascia; (4) cock-up deformity of all toes at the metatarsophalangeal joints; (5) flexion of all toes at the phalangeal joints; (6) *varus* deformity of the heel; and (7) the heel, usually *not in equinus,* is found to be in neutral or slight calcaneus. Calcaneal tendon lengthening thus is not desirable unless roentgenogram shows fixed equinus.

The etiology of cavus is not known. Local muscle imbalance may cause it. Commonly, such conditions as spondylolisthesis, spina bifida, diplomyelia, Friedreich's ataxia or involvements of certain spinal nerve tracts produce the condition.

A flexible cavus foot is defined as one that corrects easily by pushing up on the first metatarsal bone and in which the *heel may be placed manually into 3° to 5° of valgus.*

This form of cavus and between this form and the markedly rigid and deformed cavus are the types of foot that yield to fusion of the first metatarsocuneiform joint or, at

* Presented at the meeting of the Association of Bone and Joint Surgeons held in Havana, Cuba, on April 6, 1957, and at the Sixth Surgical Service, City Hospital, Boston, Mass., on May 4, 1957.

† Chicago, Ill.

‡ Chief Surgeon, Shriners Hospital for Crippled Children, Shreveport, La.

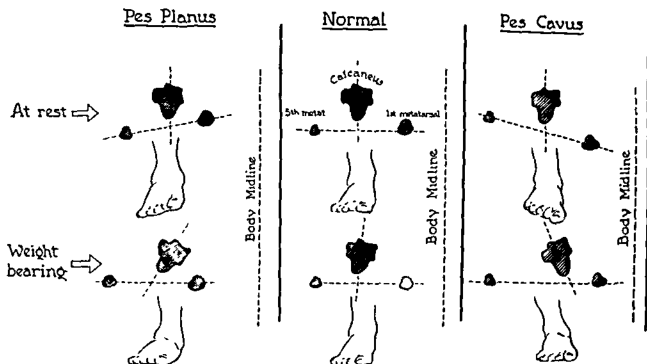


FIG. 1. Illustrates how the heel follows the forefoot. In flatfoot, to get the elevated and supinated first metatarsal to the ground, the heel assumes valgus. In cavus, because of the depressed and pronated first metatarsal, to get the fifth metatarsal to the ground the heel assumes varus. The operation advocated here shifts the first metatarsal to the position encountered in flatfoot. Once this is done, a heel able to get into valgus will do so.

times, the adding of the naviculocuneiform joint to the fusion mass.

THE PROCEDURE (Figs. 1-3)

PLASTER WEDGINGS

We have followed the principle that the correction of any fixed deformity of the foot severe enough to require surgery should be preceded by a series of plaster wedgings. The wedgings correct both the rear foot and the forefoot conditions by stretching the soft tissue and softening the bone. When the wedgings have placed the foot in an overcorrected position, or when as much correction as possible has been gained, surgical stabilization is carried out. Wedgings eliminate removal of large pieces of bone to get functional lengthening of soft tissue. The cartilage comes off the bone with little effort; therefore, the bone need be little disturbed. The foot retains all possible length

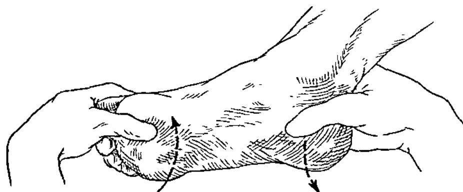
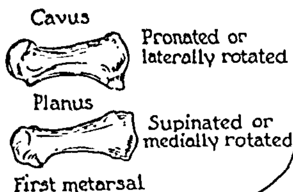
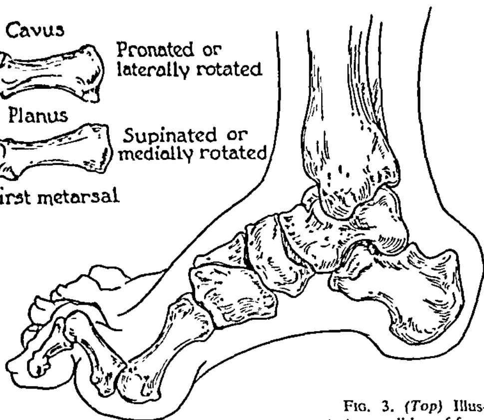


FIG 2. Previous to surgery the foot should be flexible, so that the first metatarsal may be supinated and elevated and the heel placed in valgus attitude. This movement alone relaxes the plantar fascia, and the toes straighten at the metatarsophalangeal joints. This position is maintained in plaster after surgery.





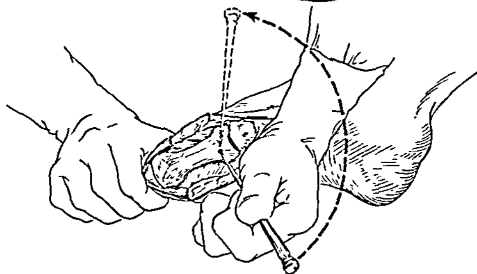
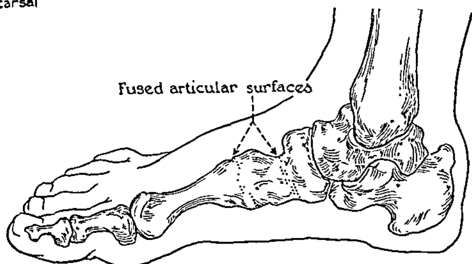


FIG. 3. *(Top)* Illustrates condition of forefoot in cavus. Note the additional drop of first metatarsal over its fellows. *(Center)* Exposure diagrammed. After the metatarsocuneiform joint is denuded, the metatarsal is elevated and rotated. While the metatarsal is held in firm contact and in the corrected position, the fixation wires are driven. *(Bottom)* Completed procedure.



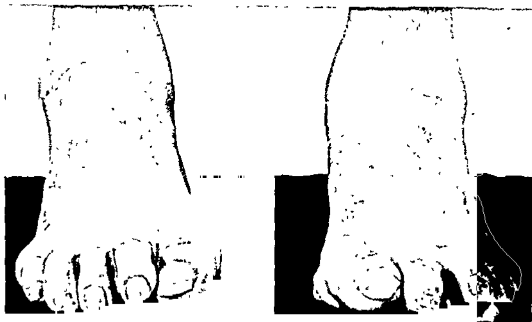
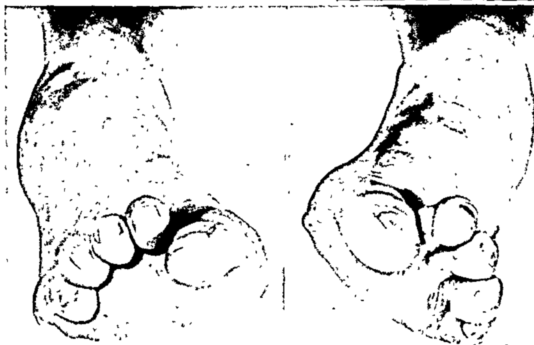




FIG. 4. *(Top)* Result of first metatarso-cuneiform fusion in left foot 2 years after operation. Cavus was more marked on left than on right Patient a male adult. *(Center)* Shows behavior of heel after first metatarsal correction on left. *(Bottom)* With patient supinating forefeet, note alignment of first metatarsal on left as opposed to right foot. Plaster wedgings preceded surgery.



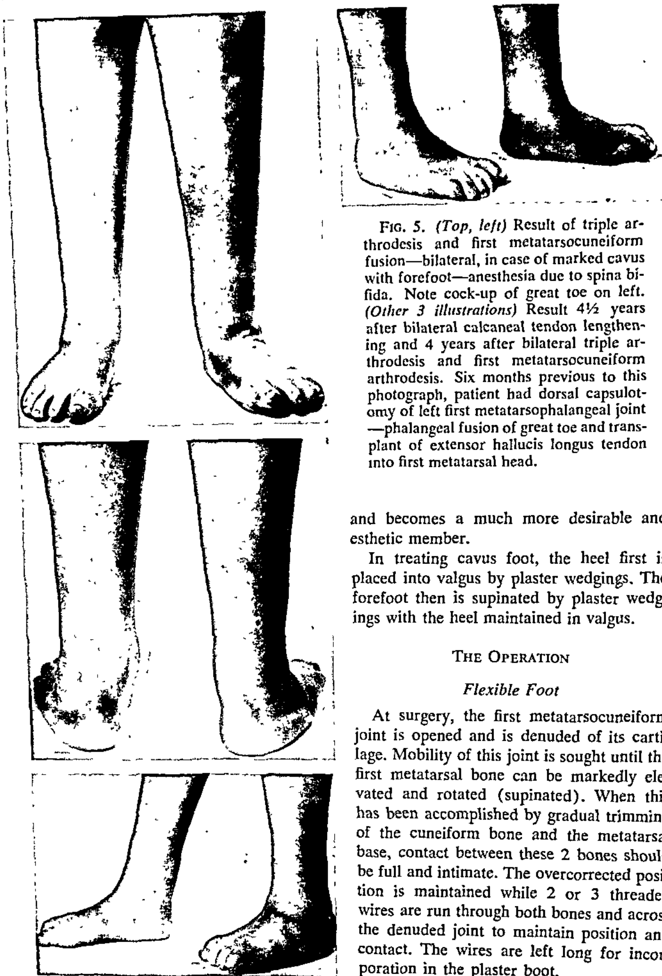


FIG. 5. *(Top, left)* Result of triple arthrodesis and first metatarsocuneiform fusion—bilateral, in case of marked cavus with forefoot—anesthesia due to spina bifida. Note cock-up of great toe on left. *(Other 3 illustrations)* Result 4½ years after bilateral calcaneal tendon lengthening and 4 years after bilateral triple arthrodesis and first metatarsocuneiform arthrodesis. Six months previous to this photograph, patient had dorsal capsulotomy of left first metatarsophalangeal joint —phalangeal fusion of great toe and transplant of extensor hallucis longus tendon into first metatarsal head.

and becomes a much more desirable and esthetic member.

In treating cavus foot, the heel first is placed into valgus by plaster wedgings. The forefoot then is supinated by plaster wedgings with the heel maintained in valgus.

THE OPERATION

Flexible Foot

At surgery, the first metatarsocuneiform joint is opened and is denuded of its cartilage. Mobility of this joint is sought until the first metatarsal bone can be markedly elevated and rotated (supinated). When this has been accomplished by gradual trimming of the cuneiform bone and the metatarsal base, contact between these 2 bones should be full and intimate. The overcorrected position is maintained while 2 or 3 threaded wires are run through both bones and across the denuded joint to maintain position and contact. The wires are left long for incorporation in the plaster boot.



If the first metatarsal drop is marked, additional correction is easily obtained by fusing the naviculocuneiform joint after full correction and stabilization of the metatarsocuneiform joint have been completed.

A plaster boot is applied with the *forefoot supinated and the heel in valgus.* Both positions of supination and valgus are as extreme as one can get without jeopardizing the soft tissue or the circulation. At the end of 5 weeks, the wires are exposed in the plaster and spun out. A walking sole is provided.



FIG. 6. *Result in case of right calcaneal tendon lengthening and first metatarsocuneiform fusion.*

The boot is removed at the end of 9 weeks. If roentgenogram shows union at the metatarsocuneiform joint, a self-adhering gauze stocking is provided and the patient starts weight-bearing.

The Rigid Foot (Markedly Deformed and Rigid Foot)

The plaster wedgings achieve as much valgus of the heel and supination of the forefoot as possible.

The metatarsocuneiform fusion is done first, and this correction is secured by threaded wires before the triple arthrodesis stabilizes the rearfoot. The heel and the forefoot must be lined up for correct weight-bearing in the stabilized position. The supination of the first metatarsal must not involve the rest of the foot to any marked degree because of the rearfoot stabilization One must be sure to get the heel into a full 5° of valgus. If previous plaster wedgings of sufficient efficiency have been applied, this is easily accomplished without removing large sections of bone.

In some of our cases the cock-up of the great toe upon its metatarsal has constituted a subluxation that precluded the raising of the first metatarsal. A radical dorsal cap-



FIG. 7. Result following bilateral triple arthrodesis and first metatarsocuneiform fusion. Note effect on cock-up deformity of toes of each foot. Cavus due to Friedreich's ataxia.



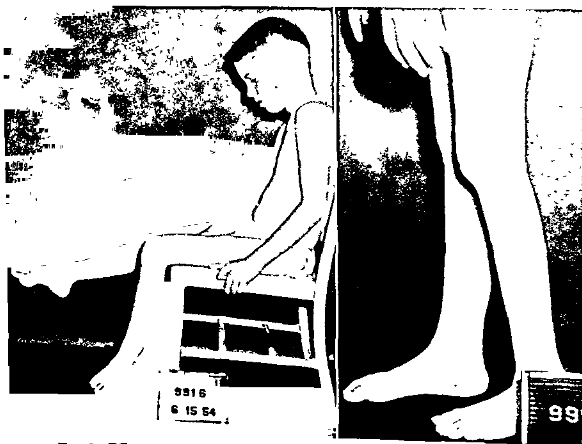


FIG. 8. Effect of first metatarsocuneiform fusion 20 months after surgery.

sulotomy, combined at times with transplantation of the extensor hallucis longus tendon to the metatarsal neck and phalangeal fusion, has corrected this situation. In these cases, care has been taken to see that the plaster boot holds the great toe in plantar flexion with the metatarsal well elevated.

The Results (Figs. 4-8)

We have been doing this procedure for *over 12 years. We have reversed the procedure* for treating flatfoot in the child. In children with flatfoot, the lowering of the metatarsal puts more weight upon it, but the flexibility of the proximal joints in the foot rapidly neutralizes the first metatarsal shift. In cavus foot, the order of application of force is in reverse, and the correction is permanent.

In the child it is thought better not to have the wires pass through the epiphyseal plate at the base of the first metatarsal bone. This is avoided by taking most bone away from the cuneiform and putting the wires only through the epiphysis and thus missing the plate. In our opinion, if one wire need be passed through the plate, the harm done is more of opinion than of fact.

CONCLUSIONS

*A new operation is presented for the cor*rection of flexible cavus foot. This procedure is of great value when combined with rearfoot correction and stabilization in the treatment of rigid cavus foot.

The result of this procedure alone in correctly chosen cases and when combined with triple arthrodesis in others has given the best-looking feet and the best functional correction that we know of.

Un Nove Operation pro le Correction de Pede Cave (Fusion del Prime Articulation Metatarso-Cuneiforme e del Articulation Naviculo-Cuneiforme)

Summario in Interlingua

Es presentate un nove operation pro le correction de flexibile pede cave. In le tractamento de rigide pede cave, illo es de valor quando combinate con correction e stabilisation del pede posterior.

In casos correctemente seligite, le application del technica—sol o in combination con triple arthrodeses—ha resultate in pedes del melior apparentia e del melior grado de correction functional que nos cognosce.

12

The Enigma of Low Back Pain*

ALEXANDER LICHTOR, M.D., AND JOSEPH LICHTOR, M.D.

Over a decade ago Brailsford[1] wrote that there was probably no problem in clinical medicine which had been the cause of so much controversy as sciatica. It is true today. Diagnoses vary from neuritis, sacroiliac strain and lumbosacral arthritis to ruptured disk. The inciting causes have included trauma, exposure to cold, gout, hysteria, sensitivity to certain foods and septic foci in teeth, tonsils, gallbladder and respiratory and the gastro-intestinal tract. Treatment also ranges from manipulation, locally applied heat and massage, back support and medications to surgery.

In order for any pain to be present there must be appropriate sensory nerve endings which are described as bare and without specialized end-organs.[5] Such nerve endings are present in ligament, muscle, fascia and bone but absent in the nucleus pulposus. This is most significant, as the current popular explanation of back pain is that of a protrusion of the nucleus pulposus from within a lumbar intervertebral disk into the vertebral canal. Copious nerve endings are found in the anterior and the posterior longitudinal ligaments, as well as the posterior annulus fibrosus.[3,6] Here the ligamentous tissue is the important structure, and only when it is damaged by stretching or tearing can the underlying nucleus pulposus exert any influence on pain. Changes such as protrusion or post-traumatic thinning of the intervertebral disk arise secondarily from these ligamentous changes.

Another questionable concept is that pressure on a spinal nerve by a bulging, or protruding, posterior longitudinal ligament results in sciatica. This nerve has sensory, motor and reflex functional components which may be altered by direct pressure or irritation. For example, direct pressure on the radial nerve in the axilla or the lateral popliteal nerve over the fibula produces wristdrop or footdrop plus paresthesia but not pain. From this it is doubtful that pressure on a spinal nerve within the vertebral canal will cause pain. It is likely that sciatic pain comes from alterations of the ligamentous fibers.

There are other factors in the etiology of low back pain. Intervertebral disk thinning effects an overriding and malalignment of the lateral intervertebral joints. The pain under this condition arises from the stretching of the capsule, which is fibrous tissue surrounding the joints and well supplied with sensory nerve endings. Also, trauma can change the structure of the supraspinous and the interspinous ligaments. Spondylolisthesis, too, is subject to difference of opinion as to etiology and treatment. Pain from this source will result because of tearing of the fibrocartilaginous tissue which fills the defect of the pars interarticularis. According to Gill and White,[2] excision alone of the affected tissue will relieve the back pain.

Even surgery has its different motivations as to whether spine fusion should or should

* From the Division of Orthopaedic Surgery, Menorah Hospital, Kansas City, Mo.

not be tried. Both the orthopaedic surgeon and the neurosurgeon may operate for the so-called disk lesion. There have been statistical attempts to prove or to disprove the superiority of bone-grafting procedures.[4] Some orthopaedic surgeons do not perform surgery unless a bone graft is used, hence a human element may enter into their evaluation of the end-results. In the past, benefit from surgery has been ascribed to bone grafting. Nevertheless, in spite of the different technics, bony union takes place in approximately 60 per cent of the cases, but more than this number get relief from the surgery.[7] Therefore, the benefit from surgery must come from something other than the stabilizing or the fusing of the spine. As stated previously, the sensory nerve endings for pain lie in the ligamentous structures. By excision of the supraspinous and the interspinous ligaments and the lamina with the spinous process, the possible sources of irritation are eliminated. If the lesion is spondylolisthesis, the removal of the involved tissue eliminates the cause of pain. In osteoarthritis the affected joint may be excised and a bone graft used to eliminate its motion. It seems apparent that excision of the stretched capsule about the lateral intervertebral joint alone actually relieves the pain. With a protruding longitudinal ligament it should be pointed out that its fibers are cut prior to the removal of the nucleus pulposus. After the stretched ligamentous fibers are incised there is relief from pain. It is evident that when affected tissues are excised and/or incised, pain may be relieved even though a surgical procedure presumably was for another purpose.

CASE REPORTS

Case F. P. A service-station attendant, 49 years old, complained of low back pain of 22 years' duration after being knocked down by a heifer Previous treatment had been a plaster body jacket and many spine manipulations, each making him worse A week prior to our examination he was unable to stand because of severe low back pain. Pain radiated down the right lower extremity, which also was paresthetic. Examination revealed positive right leg signs and 1½ inches atrophy of the right thigh. The right leg and foot were hypesthetic, and active right foot motions were weak Roentgenograms of the spine were not diagnostic. Cerebrospinal fluid study showed no cells and 74 mg. total protein. At surgery the vertebral canal was approached at the L-4 to L-5 level on the right, since the right ankle jerk reflex was normal. A huge intervertebral disk protrusion was found with the overlying posterior longitudinal ligament stretched but grossly intact. On incising the ligament a large piece of nucleus pulposus under pressure exuded into the canal. Convalescence was uneventful, and the patient returned to his work in 1 month.

In this case the severe back pain may be ascribed to the extreme stretching without complete rupture of the posterior longitudinal ligament. Incision of the ligamentous fibers relieved the pain, and excision of the bulging nucleus pulposus removed direct pressure from the nerve.

Case B. M. A man 55 years of age complained of low back pain of 6 months' duration that disappeared suddenly 2 weeks prior to the first examination. His chief complaint at that time was numbness of the right leg and foot dorsolaterally. Right leg pain was relieved by flexing the spine and the hips. On examination, percussion tenderness was present over the right lumbosacral area. Leg signs were positive on the right, and the right ankle jerk reflex was absent. The right foot was hypesthetic over its dorsolateral aspect, and active right foot dorsiflexion was mildly weakened. Roentgenographic examination showed some thinning of the lumbosacral disk. Surgical exposure of the lumbosacral disk on the right showed a free-lying nucleus pulposus. This was removed. The patient returned to light work 1 month after surgery with no pain in the back or the right lower extremity.

This typifies back pain that disappears suddenly and a lower extremity becomes involved in sensory, motor and reflex changes. Obviously, the back pain disappeared when the protruding posterior longitudinal ligamentous fibers ruptured completely. The nucleus pulposus then exuded and pressed against the nerve, crossing the disk, and lower extremity nerve involvement resulted.

Case I. E. A man 49 years of age had low back pain for 2 years. He was injured 2 years prior to the onset of the back pain. Earlier treatment included urologic investigation, physiotherapy and a back support. Psychiatric consultation was being considered. The lower lumbar spine was tender to the right of the midline. The paralumbar muscles exhibited spasm, and lumbar flexion and extension were limited slightly because of pain. Leg signs were negative, and roentgenograms were not unusual. The cerebrospinal fluid yielded 78 mg. total protein. Because of the man's mental attitude and the elevated spinal fluid protein, a myelogram was performed reluctantly. A definite defect was seen at the L-4 to L-5 level on the right. On partial excision of the fourth and the fifth lumbar laminae on the right, plus their spinous processes, a protruding posterior longitudinal ligament was exposed and incised, and the nucleus pulposus was removed. Rapid recovery followed, and the patient returned to his store 6 weeks after operation.

In this patient a protruding or stretched posterior longitudinal ligament gave rise to back pain without radiation down a lower extremity. When the bulging ligament is not pressing directly on a nerve, there will be no sensory, motor or reflex changes in a lower extremity. The complete cutting and interruption of the continuity of the posterior longitudinal fibers relieved the pain, not the removal of nucleus pulposus material.

Case H. A. A 32-year-old mechanic fell 10 feet from a platform and then noted low back pain. For 10 months before his first examination by us he had been receiving physiotherapy, medications and a back support for severe localized low back pain. The low back was markedly tender over the lumbosacral spinous processes, and extension of the lumbar spine was painful and limited. Roentgenograms revealed sacralization of the fifth lumbar vertebra with widening of the transverse processes and a spina bifida occulta. The damage was considered to be in the soft tissue of the L-5 to S-1 interspinous area, hence surgery 14 months after injury was directed at its excision, along with a complete laminectomy of the fifth lumbar vertebra. The man returned to light work 6 weeks after surgery with absence of pain.

In this case back pain was disabling for over a year. By excision of the supraspinous and the interspinous ligaments between the fourth lumbar spinous process and the sacrum, the site of pain origin was eliminated. If a bone-grafting procedure had been attempted, the interspinous ligamentous tissue would have been excised. However, the good result would have been ascribed to the bone graft and not to the excision of the soft tissue. In our opinion, the good from surgery comes from removal of the affected tissue.

Case E. H. A mechanic, 36 years old, had injured his back 6 years previously when he fell out of a truck. Low back pain recurred, especially after physical activity, and was relieved by rest. The left lower extremity had shortened and atrophied through infantile paralysis at the age of 3 years. Roentgenograms demonstrated an obvious Grade 1 Spondylolisthesis. The man returned to work without any pain 3 weeks after complete laminectomy of the fifth lumbar vertebra and excision of the fibrous tissue within the defect between the pars interarticularis.

In this case the actual definitive surgery was merely the excision of the tissue lying within the defective pars interarticularis, yet relief from pain was almost immediate—another example of relief from pain by excision of the affected tissue.

Case L. C. Without history of injury, a 31-year-old woman complained of right leg pain of 2 weeks' duration. Physical activity and weight-bearing on the right leg caused increase of right leg pain and also some back pain. The right foot felt numb. Examination revealed punch tenderness over the right lumbosacral area. The right leg signs were markedly positive, and the right ankle jerk reflex was absent. The right leg and foot were hypesthetic, and active right foot dorsiflexion was weak. Roentgenograms showed flattening of the lumbar spine and thinning of the lumbosacral disk. After being observed for 4 days it was noted that the right thigh had become atrophied by ½ inch in circumference, and the patient's complaints were marked numbness and weakness of the right leg and foot without back pain. Cerebrospinal fluid total protein was 40 mg. On the 19th day after onset of symptoms surgery was performed. After the right lamina of the fifth lumbar vertebra was removed a large amount of extruded nucleus pulposus was seen.

This was taken out without the posterior longitudinal ligament's requiring incision. Except for return of the right ankle jerk reflex, she made a rapid and excellent recovery.

This case illustrates the minimal back pain present when the longitudinal ligament is completely torn, yet sensory, motor and reflexes changes in the affected lower extremity were marked from direct pressure on the nerve traversing the lumbosacral disk.

Case P. B. A woman of 46 slipped on an oily floor and twisted her back. She was treated elsewhere for 5 weeks with physiotherapy and a back support for low back pain and right lower extremity paresthesia and weakness. Six months after injury a myelogram was done and surgery performed, the lowest two right lumbar disks being explored. Subsequently the back was injected seven times, and a myelogram was repeated. A steel back brace was prescribed, but after performing light work for 6 months she was unable to return to work 1 year after surgery.

On our first examination 2 years after injury she was in obvious pain and walked with care and a right leg limp. The low back was markedly tender over the right paralumbar muscles. Lumbar extension and flexion were painful and moderately limited. Leg signs were positive, and the right ankle jerk reflex was absent. A thin lumbosacral disk and pantopaque material within the vertebral canal were seen on the roentgenograms. Operative treatment consisted of complete removal of the fifth lumbar vertebral laminae. Much improvement resulted, and the patient returned to light work 3 months postoperatively.

In this case the main difficulty was back pain and tenderness. Excision of scar tissue and the fifth lumbar laminae without attempting a spine fusion produced much relief from pain.

COMMENT

From a theoretic viewpoint, pain arises from irritation of sensory nerve endings. In the low back, these sensory nerve endings are to be found in soft tissue such as ligamentous fibers but not in the nucleus pulposus. Thus, back and lower extremity pains result from stretching of ligamentous fibers and not from nucleus pulposus protrusion. With pressure against a nerve, sensory, motor or reflex change may develop in a lower extremity. Pain is relieved when the affected tissue is excised or incised. Removal of the nucleus pulposus beneath a bulging posterior longitudinal ligament will relieve the sensory, motor or reflex changes resulting from nerve pressure. Surgery for the relief of back pain with or without lower extremity radiation should always include excision of the lamina and its spinous process, along with the supraspinous and the interspinous ligaments. In a posterior longitudinal ligamentous protrusion the ligament is incised and the nucleus pulposus removed. With a spondylolisthesis, the laminectomy is bilateral, and the scar tissue across the defective pars interarticularis must be excised. In the surgical treatment of the abovementioned lesions, the use of bone transplants in an attempt to secure spine fusion remains open to question.

CONCLUSIONS

The nucleus pulposus has no nerve endings; therefore, it cannot produce pain.

Ligamentous alterations precede intervertebral disk protrusions or thinning.

Pain in sciatica follows ligamentous tears.

Relief from back pain is obtained by incision or excision of involved ligamentous tissue.

REFERENCES

1. Brailsford, James: The Radiology of Bones and Joints, ed. 3, p. 116, Baltimore, Williams & Wilkins, 1945.
2. Gill, Gerald G., and White, Hugh L.: Mechanism of nerve-root compression and irritation in backache, Clinical Orthopaedics No. 5, pp. 66-78, Philadelphia, Lippincott, 1955.
3. [illegible] vertebraux, Presse [illegible]
4. Nachlas, I. William: End-result study of the treatment of herniated nucleus pulposus by excision with and without fusion, J.

Bone & Joint Surg. 34-A:981-988, 1952.
5. Purves-Stewart, James, and Worster-Drought, C.: The Diagnosis of Nervous Diseases, ed. 10, p. 34, London, Arnold, 1952.
6. Roofe, P. G.: Innervation of annulus fibrosus and posterior longitudinal ligament, Arch. Neurol. & Psychiat. 44:100-103, 1940.
7. Shaw, E. G., and Taylor, J. G.: The results of lumbosacral fusion for low back pain, J. Bone & Joint Surg. 38-B:485-497, 1956.

Le Enigma del Dorsalgia Inferior

Summario in Interlingua

Dorsalgia presenta un problema quanto al natura exacte de su causa. Modas ha venite e disparite in re su diagnose e su tractamento. Evidentemente, dolores pote esser notate solmente ubi il existe terminos de nervos sensori pro le reception de signales dolorose. Tales ha non essite trovate in le nucleo pulpose, sed illos existe in le tessuto molle, specialmente in ligamentos e in capsulas que coperi faciettas articular. Le pression directe super un nervo pote afficer su functional componentes sensori, motori, o reflexe sin causar ulle dolor. Ergo, quando le ligamento postero-longitudinal es debile, le nucleo pulpose pote protruder, coperite per tense fibras ligamentose. Isto es dolorose, e si un pression es exercite super un nervo, le resultato es alterationes sensori, motori, o reflexe. Si il existe nulle pression super un nervo, nulle manifestationes occurre in le gambas. Del altere latere, si le fibras ligamentose es completemente rumpite, le dorsalgia es minimal o absente. Le pression super le nervo depende del loco del extrudite nucleo pulpose.

Le tractamento chirurgic de dorsalgia inferior resulta in bon successo quando un incision es effectuate in le tessuto interessate, i.e. per exemplo in le tense fibras ligamentose que coperi le protrusion de nucleo pulpose. Le excision del ligamento interspinose o del capsula articular es etiam efficace, si iste tessutos es interessate. Isto explica le bon successos resultante del varie processos chirurgic que ha in commun le incision o excision de tessuto. Le elimination del pression exercite super un nervo contribue al alleviation del alterationes sensori, motori, o reflexe, sed iste mesura non affice le dolores del dorso o del extremitates inferior.

Es presentate casos illustrative que demonstra le supra-mentionate conceptos in re le production de dolores e de alterationes sensori, motori, e reflexe e le rationes pro que le intervention chirurgic pote effectuar un alleviamento del symptomas.

13

Management of the Acute Low Back Syndrome: A Practical Plan

LASZLO ORMANDY, M.D.*

The acute low back syndrome is a relatively common and totally disabling disorder that causes great economic loss to industry as a whole and to laborers and white-collar workers alike. As a rule, it is the industrial surgeon or the general practitioner who is depended upon for diagnosis and treatment of this ailment. Familiarity with this syndrome will permit him to relieve the distress, expedite recovery and, by diminishing the duration of the disability, allow the patient to return earlier to gainful employment.

When a patient with a complaint of an acute onset of low back pain consults the physician, often it is impossible to carry out a complete physical examination and make an exact diagnosis because of the severity of the existing pain. He takes a short history and completes a pertinent physical examination.

The author offers here a practical plan of conservative management of patients suffering from acute low back pain based upon successful results in a series of 35 patients who had developed acute low back pain with or without sciatic scoliosis following trauma incident to their usual physical activities, as in lifting objects improperly, lifting or attempting to lift heavy objects accompanied by an awkward twisting of the trunk upon the pelvis.

Invariably it has been our finding that there is present in such patients severe spasm of skeletal muscle overlying the injured site and that relaxation of this spasm relieves pain promptly. Therefore, we concentrate on the treatment that will relieve the spasm and the accompanying pain, whether due to sacro-iliac or lumbosacral strain or sprain, myofascitis, ruptured intervertebral disk, sacro-iliac displacement, facet-synovial impingement or other causes whose exact etiology finally is ascertained. The relief of the acute pain permits the completion of the physical examination, including diagnostic orthopaedic tests and roentgenograms of the lumbosacral spine.

HISTORY

Usually the patient states that sharp pain developed during a twisting motion of the spine while he was leaning over or lifting or pulling a heavy object. Occasionally he relates that he and a co-worker were lifting an object jointly when the latter suddenly let go and the weight of the entire load fell unexpectedly on him. Often he has heard or felt something snap low in his back and coincidentally either became totally incapacitated at that time or found that he was unable to get out of bed the next morning because of severe low back pain. The pain of the acute low back syndrome is sharp,

* Attending Orthopaedic Surgeon, Howard University School of Medicine, and Associate Orthopaedic Surgeon, Emergency Hospital, Washington, D. C.

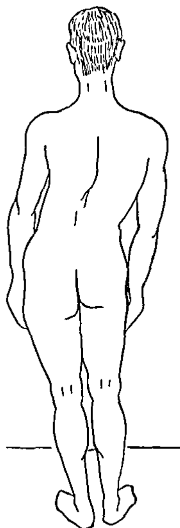


FIG. 1. Sciatic scoliosis.

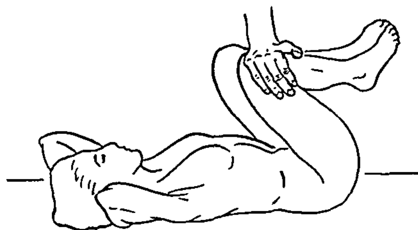


FIG. 2. Pelvic rocking test.

severe and constant. It is located across the lower back on one side or the other. It is aggravated by the slightest movement, forward flexion, lateral flexion, twisting or extension of the lumbosacral spine. There may be radiation to one buttock or the other, or to both, to the groin on one or both sides or down the back of the thigh or the leg on one side or the other. The pain may be worse on coughing or sneezing. In severity the pain of the acute low back syndrome may resemble that of renal colic.

EXAMINATION OF THE BACK AND THE LOWER EXTREMITIES

Because of the severe pain aggravated by the slightest movement of the spine, we make the first examination brief and limit it to the back. The patient should be undressed and draped so as to expose the back and the lower extremities.

The patient is seen to walk with a shuffling gait, the body flexed slightly forward and to one side, the entire back being held rigid. The trunk tends to list away from the painful side (sciatic scoliosis, Fig. 1); however, this listing is variable. The ilium on the painful side is less prominent. All movements of the trunk upon the pelvis are restricted.

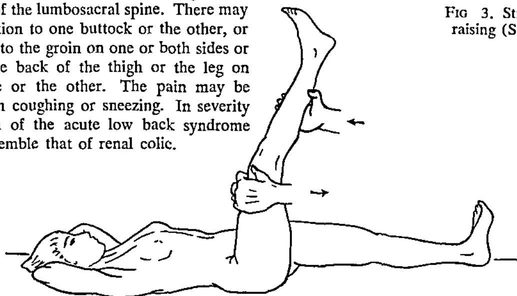


FIG 3. Straight-leg-raising (SLR) test.

Straightening up from forward flexion is particularly painful. Rising from a chair is done with great difficulty, while lying on the examining table is almost intolerable. Spasm of the erector spinae muscle is present. Such spasm is a protective mechanism to limit movement and prevent pain.

Palpation of the spine for tender areas affords important diagnostic information and, *therefore, is a therapeutic guide. Point* tenderness may be elicited by palpating the spinous processes of the lumbar vertebrae, the interspinous ligaments between L-4 and L-5 and between L-5 and S-1, the ilio lumbar ligaments and the posterior sacro-iliac ligaments. At times the tenderness is diffused over the entire low back.

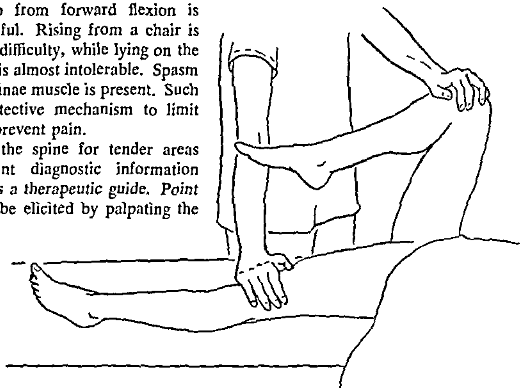


Fig. 4. Gaenslen's sign (modified).

Further information may be obtained from a study of the movements of the spine. These are limited markedly and associated with excruciating pain in the low back. At times the patient can flex his spine, but the movement takes place in the hips, while the entire vertebral column is held rigid.

Other tests which furnish information are:

The Rocking Test (Fig. 2). Passive flexion of the pelvis on the lumbar spine by the examiner, the hips and the knees being flexed. This movement will be painful and limited if the pathology is located in the lumbosacral joint.

The Straight-Leg-Raising (SLR) Test (Fig. 3). Passive flexion of the thigh with the knee extended will put rotary stress in the sacro-iliac joint and will limit pain to the involved side, regardless of the leg tested. The same test will stretch the nerve

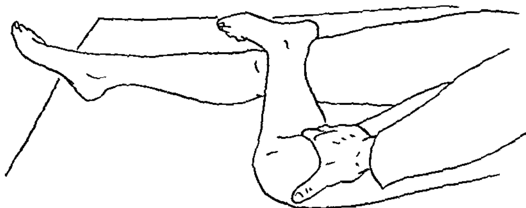


Fig. 5. Patrick test.

roots over a ruptured intervertebral disk, thus limiting the elevation of the extremity and producing the sciatic type of pain.

Gaenslen's Sign (Fig. 4). The hip and the knee of the involved side are placed in a rotary stress that results in pain.

At times the last two signs may be negative, but the Patrick test usually is positive.

Patrick Test (Fig. 5). This test will produce pain in the affected sacro-iliac joint on forcing the hip of the affected side into flexion, abduction, external rotation and extension with the knee flexed.

Sensory, reflex and motor power examinations usually are negative.

The patient will have difficulty in crossing his legs, because this movement will put extra pull on the sacro-iliac joint structures.

AIM OF TREATMENT

Speedy relief of pain is important to the physical and the emotional well-being of the patient with acute low back syndrome. The maintenance of such relief is equally important from an economic standpoint.

Our therapeutic agents include:

1. Tubadil* to achieve skeletal muscle relaxation
2. Nerve blocks of the posterior divisions of S-1 and S-2 and injection of a local anesthetic into the sacro-iliac and the lumbosacral apophyseal joints
3. Pelvic traction
4. Immobilization of the lumbosacral spine with a fitted orthopaedic corset.
5. Postural exercises

This therapeutic regimen is carried out as conveniently in the office as in the hospital.

THERAPEUTIC AGENTS AND PROCEDURES

Tubadil

The vial of Tubadil is held under hot running water or in a warm-water bath for a few minutes in order to liquefy the suspending menstruum and then is shaken vigorously to distribute the alkaloid evenly. A 2-cc. syringe with a 1½- to 2½-inch 20-gauge needle is used, the length of the needle being dictated by the thickness of the overlying gluteal pad of fat. Tubadil is injected deep into the upper outer quadrant of the gluteal muscle mass.

Rationale. Skeletal muscle spasm occurs as a protective reflex response incidental to trauma. Once established, such spasm produces pain *not only at the site of injury* but in contiguous muscles as well, since these become hypertonic and knotted by secondary reflex mechanisms.

Relaxation of such skeletal muscle spasm is made physiologically possible by the use of tubocurarine, whose primary point of action is a peripheral one, that is, at the neuromuscular junction. By inhibiting the transmission of impulses along motor-nerve pathways, tubocurarine relieves the spasm and its subjective component, pain.

Tubadil relieves muscle spasm within 45 minutes and maintains this relaxation, with consequent relief of pain usually for about 24 hours, occasionally longer.

Dose. We have overcome the serious disadvantages of aqueous tubocurarine by employing Tubadil, a long-acting curare preparation containing 25 mg. of highly purified crystalline tubocurarine in a specially developed repository menstruum. Because of its gradual and nonsporadic release of tubocurarine, we have been able to use this muscle relaxant in low doses: 0.7 cc. (17.5 mg.) tubocurarine for ambulatory patients and 0.9 cc. (22.5 mg.) for hospitalized patients. With this low dosage we have achieved relatively speedy relaxation of spasm and relief of pain in 30 to 45 minutes following the intragluteal injection. We have found that relaxation of spasm and relief of pain may be maintained for as long as 24 hours per injection.

We never have encountered any serious side effects requiring artificial respiration or

* Grateful acknowledgment for generous supplies of Tubadil is made to Dr. Edward A. Barrett, Medical Director, Endo Laboratories Inc.

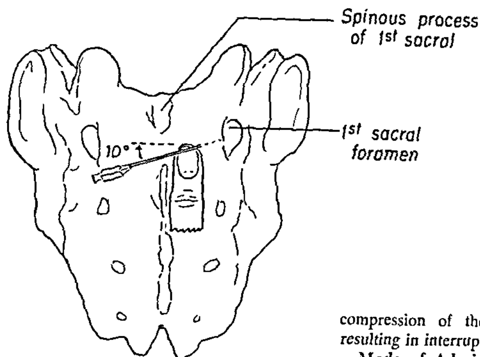


FIG. 6. Diagram showing the mode of injection of S-1 and S-2 nerves (posterior primary division). The needle is inserted one fingerbreadth lateral to the spinous process between the first and the second foramina. Pass the needle in an anterolateral direction at an angle of 10° to the skin and also point the level of the needle 10° cephalad or caudad until bone is struck.

the limited antidote neostigmine. Blurring of the vision or diplopia has occurred occasionally. Patients were advised in advance regarding this possibility; therefore, if it did occur, they were not too concerned about it.

We have found that generally Tubadil need not be given more than three or four times to each patient. The usual interval between the small doses in office patients is 48 hours, while hospitalized patients received daily alternating doses of 0.9 and 0.4 cc. so long as there was spasm with pain.

Our latest experiences with Tubadil have demonstrated that it helps eliminate the need for frequent and prolonged individual diathermy treatments.

Nerve Block

Satisfactory nerve blocks can be accomplished only if topographic anatomy is followed. Using Pontocaine (1) we block the posterior divisions of spinal nerves S-1 and S-2, (2) inject the sacro-iliac joints or (3) infiltrate the lumbosacral apophyseal joints, depending upon our physical findings.

Rationale. The local anesthetic reduces the number and the intensity of peripheral sensory stimuli and thus reduces pain. The direct effect of the Pontocaine is explained by the swelling of the myelin sheath with compression of the nerve cylinder itself, resulting in interruption of impulses.

Mode of Administration. The patient is placed on the examining table face down and with the pelvis elevated by a pillow. The low back region is painted with a stainless tincture Zephiran. Thirty-two cc. of 0.15 per cent Pontocaine is used, 1 ampule of hyaluronidase and 3 drops of 1:1,000 Adrenalin being added. A 10-cc. syringe and a 2½-inch 22-gauge needle are required.

To locate the site of injection the following landmarks should be used as a guide: the second sacral foramen is located one fingerbreadth medial and an equal distance caudad to the posterosuperior spine of the ilium; the first sacral foramen is one fingerbreadth (¾ inch) cephalad and ¾ inch medial to the posterosuperior spine.

In order to inject the posterior divisions of S-1 and S-2 and also the sacro-iliac joint through one needle puncture, insert the needle about one fingerbreadth (⅝ inch) lateral to the spinous process between the first and the second sacral foramina after anesthetizing the skin; pass the needle in an anterolateral direction at an angle of 10° with the skin and also point the bevel of the needle 10° cephalad or caudad until bone is struck; withdraw the needle ⅛ inch and inject 4 cc. of the anesthetic fluid into each area (Figs. 6 & 7). Next inject the sacro-iliac joint by partially withdrawing the

needle, tilt it 45° medially, so that the bevel of the needle will aim at the sacro-iliac joint, and reinsert it. At this angle the needle will pass between the sacrum and the posterosuperior iliac spine through the fibers of the sacro-iliac ligament to the posterior margin of the sacro-iliac joint (Fig. 8).

To infiltrate the lumbosacral apophyseal joint, the joint is localized by the following method:

the second sacral spinous process is at the level of the posterosuperior spine and, by palpating cephalad, the spinous process of L-5 may be felt. Or palpate the highest point on each iliac crest and draw a line between them; this line will bisect the spinous process of the fourth lumbar vertebra, thus locating spinous process of L-5. About 1 inch laterally from the tip of L-5 spinous process, the lumbosacral apophyseal joint is located. Insert the needle perpendicular to this area until the needle strikes bone and, after aspirating for blood, inject 4 cc. of the anesthetic fluid. If the needle does not strike bone after being inserted to a depth of 2½ inches, the needle must have entered lateral to the joint.

This local infiltration should be done bilaterally if unilateral tenderness cannot be localized.

Multiple resinsertion of the needle or entering into the sacral foramen should be avoided to prevent puncturing blood vessels. Improper infiltration will produce hematomas that create more muscle spasm and more pain.

If the symptoms do not disappear completely following the first block, infiltration with the anesthetic should be repeated in about 3 days.

It is interesting to note that 83 per cent of the ambulatory and 52 per cent of the hospitalized patients received only one anesthetic injection. Of office patients, 8 per cent required three anesthetic injections, and among the hospitalized patients, 15 per cent.

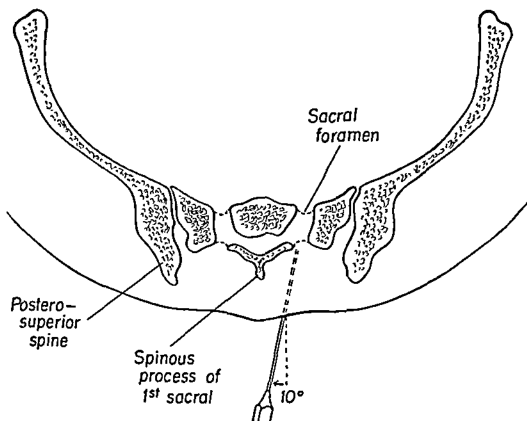


FIG. 7. Cross section of sacral region. Pass the needle in an anterolateral direction at an angle of 10° to the skin.

Pelvic Traction

First described for acute low back by Dickson in 1936 and recently by Varco, pelvic traction may be carried out either in the office or in the hospital. Often it produces immediate and striking results.

Rationale. Pelvic traction produces gradual but painless manipulation. It reduces sacro-iliac subluxation, relieves facet-synovial impingement, lessens erector spinae muscle spasm and removes nerve-root pressure symptoms caused by ruptured intervertebral disk.

Method. The foot of the treatment table or hospital bed is raised 4 inches with shock blocks for countertraction. A simple pulley device, with means for holding weights, is clamped on the end of the table. A pillow is placed under the knees of the patient in order to relax the hamstrings and to decrease lumbar lordosis. The patient lies in a canvas belt 8 inches wide and lined with felt ½ inch thick. The belt should extend from the iliac crest above to below the greater trochanters (Fig. 9).

In the office, from 40 to 50 lbs. weight is applied for 30 minutes and repeated at subsequent visits for from 30 to 60 minutes. For hospital patients, the traction should be kept on constantly, from 40 to 50 lbs. weight being used. Three times a day for 1 hour each the weights should be increased to 60 lbs. if the patient can tolerate this. It is permissible to remove the belt for from 15 to 30 minutes for rest periods and nursing care. The pelvic traction can de discontinued within 2 to 5 days.

Immobilization of Lumbosacral Spine with Corset

Rationale. A properly fitted orthopaedic corset furnishes protection of injured tissues.

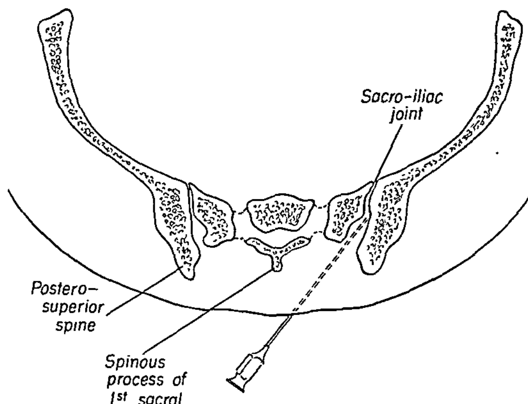


Fig 8 Cross section of sacro-iliac joints Withdraw the previously inserted needle partially, displace the skin toward the spinous process with one hand in order to be able to reinsert the needle at a 45° angle. At this angle the needle will pass between the sacrum and the posterosuperior iliac spine through the sacro-iliac ligament to the posterior margin of the sacro-iliac joint.

Fig. 9. Pelvic traction. Place a pillow under the knees or put the patient in the Fowler position.

The ambulatory patients should be fitted with a lumbosacral corset as soon as the nerve block is completed. Hospital patients are fitted with a corset immediately before their bed confinement is discontinued. The corset then should be worn for 2 or 3 months constantly when the patient is up and about. An orthopaedic corset has the following requirements: it should be long enough in front to support and lift the abdomen, and long enough in the back to encircle the buttocks and not reach the inferior tip of the scapulae. The average length of the corset in the back is 15 inches. Side lacing is preferable (Fig. 10). Two rigid steel stays should be used in the back and should be bent according to the contour of the lumbosacral spine.

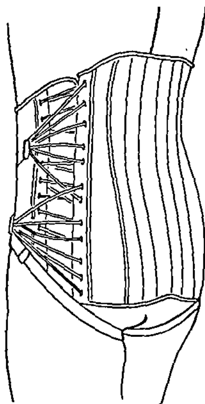


Fig. 10. Lumbosacral corset.

Postural Exercises

Rationale. Three or 4 weeks following the acute attack, physiotherapy should be

instituted to re-educate the patient's own corset muscles, that is, his abdominals and glutei, and to stretch the erector spinae muscles.

It is advisable to show the patient only 3 or 4 simple postural exercises and have him do these regularly.

A fracture board between the mattress and the spring gives firmness and support to traumatized muscles.

We have found the following postural exercises to be beneficial in reducing the lumbar curve and increasing the strength of the muscles of the anterior abdominal wall:



FIG. 11. Lie on the floor with pillow under knees and arms folded across chest. Pull chin in, flatten back against floor. Hold *position, raise shoulders about 8 inches and head. Let head and* shoulders down slowly. Relax.

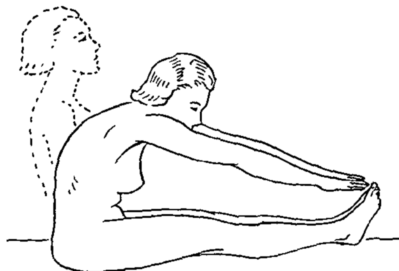


FIG 12. Seated on floor with pillow under knees, touch toes with fingertips Start from sitting position

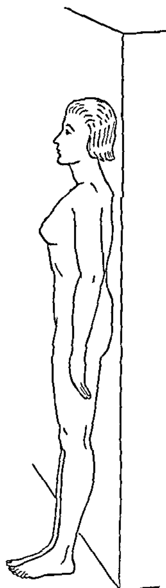


FIG. 13. With head touching wall, stand with heels about 3 inches from wall, pull chin in, flatten back against wall. Squeeze buttocks together. Draw abdomen up and in without taking a deep breath While holding abdomen up and in, count from 1 to 5 aloud. Relax.

1. Lie on the floor with pillow under knees and arms folded across chest. Pull chin in, flatten back against floor. Hold position, raise shoulders about 8 inches and head. Let head and shoulders down slowly. Relax. (Fig. 11)

2. Seated on floor with pillow under knees, touch toes with fingertips. Start from sitting position. (Fig. 12)

3. With head touching wall, stand with heels about 3 inches from wall, pull chin in, flatten back against wall. Squeeze buttocks together. Draw abdomen up and in without taking a deep breath. While holding abdomen up and in, count from 1 to 5 aloud. Relax. (Fig. 13)

Each of these exercises should be repeated 5 or 10 times, once or twice a day, for 1 year.

CASE REPORTS

Case 1. Mr. J. K., aged 40, laborer, was brought to the hospital by ambulance with severe, excruciating pain in his low back. He stated that while lifting an object he strained his back and was unable to straighten up He had no radiating pain. The physical examination could not be completed because the slightest motion on the stretcher caused excruciating pain in the low back. Marked bilateral erector spinae muscle spasm was present. There was generalized tenderness over L-4 to L-5 and L-5 to S-1 spinous processes and in the lumbosacral apophyseal joints bilaterally. The rocking test produced severe exacerbation of the pain in the low back. Gaenslen's sign was positive bilaterally; reflexes and sensory examination were normal

Roentgenograms. Negative.

Diagnosis. Acute low back syndrome, severe.

Therapy. Soon after admission to hospital, a block was done according to the described procedure, pelvic traction was applied by 45-lb. weight, and Tubadil, 0.9 cc., was injected intragluteally. The patient stated that almost all the back pain disappeared right after the Tubadil injection and the nerve block. Six days following the first injection another block was done. The patient also received daily Tubadil injections. He was fitted with a lumbosacral corset and discharged from the hospital without any complaint 7 days following hospital admission. The patient, covered by Workmen's Compensation Insurance, resumed his work 22 days after the accident.

Case 2. Mrs. R. T., aged 36, housewife, was referred to the author's office with the following history:

Four days previously she lifted an object and suddenly developed an acute sharp pain in the lower back. The pain was localized over the lumbosacral joint and was aggravated when she rose from a horizontal position. Stooping over and coughing made the pain worse. There was no radiation of pain into the thighs or the legs. However, she complained of a drawing pain on the lateral aspect of the right thigh. A year previously she had had a similar attack, for which she received osteopathic treatments for 3 months. The physical examination revealed pain associated with moderate limitation of movements of the lumbosacral joints. Reflexes and sensory examination were normal.

Diagnosis. Acute low back syndrome.

Therapy. The office treatments consisted of 3 Tubadil injections (0.7 cc. per dose every other day) and a diathermy treatment on the second and the fifth days. The patient was fitted with a lumbosacral corset. Completely relieved, she was discharged 5 days following the first visit. The patient resumed her full schedule of housework 3 days after her first treatment.

CLINICAL DATA

Thirty-five patients treated for acute low back pain are subdivided into two groups for the purpose of this report:

1. Ambulatory (office) patients
2. Hospitalized patients

Group 1—Ambulatory Patients

There were 17 ambulatory patients, of whom 12 were males and 5 females. The age range was between 15 and 40 years, the average being 32 years. There were 16 white-collar workers and 1 laborer. Duration of symptoms varied from 2 to 30 days, the average being 9 days. The number of office visits varied from 1 to 12; average, 3.9.

Therapeutic Procedures

Tubadil. A total of 22 injections were given these 17 patients.

Blocks. Ten patients received 1 block; 1 patient, 2 blocks; 1, 3 blocks.

Corset. Sixteen patients were fitted with a lumbosacral corset.

Postural Exercises. All patients continued postural exercises at home, having obtained complete relief at the time of discharge.

Diathermy. Eight patients received an average of 3.5 diathermy treatments during follow-up.

Loss of Time. Fifteen patients lost no time from employment; a housewife and a contractor lost only 3 days each.

Group 2—Hospital Patients

There were 18 hospitalized patients, of whom 12 were males and 6 females. The age range was between 27 and 40 years; the average, 36. There were 13 white-collar workers, 4 laborers and 1 liability case.

The duration of symptoms varied from 1 to 30 days; average, 10 days. The number of hospital days varied from 1 to 15; average, 5.9. Until recently it took 10 days to get a custom-made corset, which increased the hospital stay considerably. The number of follow-up office visits varied from none to 11.

Therapeutic Procedures

Tubadil. A total of 48 injections was administered to these 18 patients.

Blocks. Ten patients received 1 block; 6 patients, 2 blocks; 3 patients, 3 blocks.

Pelvic Traction. Thirteen patients had pelvic traction.

Corset. Seventeen patients were fitted with a lumbosacral corset.

Diathermy. Six patients had diathermy treatments.

Postural Exercises. All patients were instructed to perform postural exercises at home.

Loss of Working Time Following Hospital Discharge

There were 4 Workmen's Compensation patients with time lost varying from 15 to 24 days; average, 19 days. Among 13 white-collar workers, time loss varied from none to 30 days; average, 6 days; while 1 liability patient returned to work in 7 days following hospital discharge.

DIAGNOSIS

The diagnosis of all 35 patients in both groups was acute low back syndrome. These were subclassified according to the anatomic location, such as lumbosacral involvement, sacro-iliac, combined sacro-iliac and lumbosacral involvement, myofascitis of the erector spinae muscles and herniated intervertebral disks.

RESULTS

On discharge 34 patients had complete relief of the acute low back pain and resumed their original work. One patient with a ruptured disk, removed subsequently, experienced moderate relief from pain under our conservative therapeutic regimen.

DISCUSSION

The acute low back syndrome is a condition that commonly affects both white-collar workers and those engaged in heavy manual labor. Because of the commonness of this syndrome, the severity of the pain and the protracted disability, a rational mode of therapy that relieves pain quickly, prevents prolonged disability and permits an earlier return to gainful employment is desirable. In our hands, such a mode of therapy is based upon the use of Tubadil, a skeletal muscle relaxant with extended duration of effect, peripheral sensory nerve block with Pontocaine hydrochloride, pelvic traction, immobilization with orthopaedic corset and continuing postural exercises.

Our method applies equally well to office and hospitalized patients, and is based upon the use of Tubadil to provide early and prompt and prolonged relief from muscle spasm and thus relief from its painful component; Pontocaine to relieve pain by interruption of nerve impulses; pelvic traction to promote further relaxation of involved muscles and produce gentle manipulation by

distraction; orthopaedic corset to provide support to traumatized tissues; and postural exercises to assist in re-education of injured muscles.

Our 35 patients exhibiting the characteristic syndrome of the acute low back comprised 17 office patients, ranging in age from 15 to 40 years and including 5 females and 12 males, and 18 hospitalized patients, ranging in age from 27 to 40 years and including 6 females and 12 males. All manifested pain associated with a marked degree of skeletal muscle spasm involving lumbosacral and sacro-iliac regions when first examined.

The résumé of roentgenographic findings included asymmetry of lumbosacral articulation, hypertrophic arthritis, diminished lumbosacral space, increased lumbosacral angle, transitional fifth lumbar vertebra and structural scoliosis.

Under our regimen we achieved complete relief from pain and early return to compensable employment in 99.1 per cent of our patients. The total number of Tubadil injections was 70. We encountered no side effects requiring antidotal measures in either group. Occasional diplopia was complained of, but it presented no great problem. Ambulation was permitted these tubadilized patients. As regards those treated in the office, the average number of visits was 3.9; as for those hospitalized, the average duration of stay was 6 days. Our 0.9 per cent result was considered to be "fair," even though pain relief was considerable, considering that this one patient could not return to work until operated upon for removal of a ruptured intervertebral disk. Patients were followed for as long as 20 months; the average, 11 months.

The preponderance of white-collar workers and housewives over those engaged in manual labor is noteworthy: 16 office and 14 hospitalized patients were in the former category, while there were 1 office and 4 hospitalized patients in the heavy-labor group.

SUMMARY

A rational method for the treatment of acute low back syndrome based upon obtaining prompt and prolonged relief from *skeletal muscle spasm and pain is presented.*

The technic of administration of Tubadil, skeletal muscle relaxant, the establishment of nerve block with Pontocaine and the use of pelvic traction are described for use both as office and hospital procedures to effect *restoration of body mechanics by relieving muscle spasm and pain. The need* for orthopaedic corset and postural exercises to maintain the restored properly functioning mechanical state is stressed. No special skill is required to initiate and carry out this regimen, which *permits shorter convalescence and earlier return to work.*

Each one of these five agents is an integral part of the over-all scheme of management. We have followed this course of treatment in 35 patients—17 office and 18 hospitalized—and, as already *stated, have* achieved satisfactory improvement in 99.1 *per cent of them.*

ADDENDUM

Since completing the foregoing report we have used the same five-step integrated treatment on an additional 20 patients suffering from acute low backache. Our results are entirely in keeping with our findings in the original series of 35 patients.

BIBLIOGRAPHY

Brav, E. A., and Sigmond, H.: The local and regional injection treatment of low back pain and sciatica, Ann. Int. Med. 15:5, 1941.

Dickson, F. D.: Low back injuries with particular reference to the part played by congenital abnormalities, South. Med. J. 29:364-371, 1936

Fuller, J. D.: Use of slowly absorbed suspension of d-tubocurarine chloride in traumatic injury, J.A.M A. 143:789, 1950.

Haldeman, K. O., and Soto-Hall, R.: The diagnosis and treatment of sacroiliac conditions by the injection of procaine, J. Bone & Joint Surg. 220:675, 1938.

Irwig, Fred.: Treatment of low back pain with injection, Indust. Med. 8:105, 1939.
Judovich, B.: Low back pain, Indust. Med. 8: 160, 1939.
Koenig, W.: Anaesthesirung und Quellung als Heilmittel, Chirurg 17-18:680-683, 1947.
Kraft, G. L., and Levinthal, D. H.: Etiology of lumbar vertebral derangement, Surg., Gynec. & Obst. 93:439, 1951.
Lipow, Eugene G.: Slowly absorbed tubocurarine chloride in orthopedics, A.M.A. Arch. Surg. 66:312, 1953.
Steindler, Arthur: The interpretation of sciatic radiation and the syndrome of low back pain, J. Bone & Joint Surg. 22:28, 1940.
Steindler, Arthur, and Luck, J. V.: Differential diagnosis of pain low in the back, J.A.M.A. 110:106, 1938.
Tarsy, J. M.: Treatment of low back pain by regional and local analgesic injection, Indust. Med. 8:186, 1939.
Teneff, Stefano: Novocain injection, Chirurgia 11:237, 1939.
Thiemeyer, J. S., Jr., and Reed, E. F., Jr.: The use of Tubadil (repository injection of tubocurarine) in acute back strain, Clinical Orthopaedics No. 3, p. 172, Philadelphia, Lippincott, 1954.
Travell, J. and W.: Therapy of low back pain by manipulation of referred pain in the lower extremity by procaine infiltration, Arch. Phys Med. 27:537, 1946.
Varco, S. A.: New method of pelvic traction for the relief of low back pain, Surg., Gynec. & Obst. 98:760, 1954.

Le Tractamento de Acute Dolores Infero-Dorsal

Summario in Interlingua

Es presentate un reporto del tractamento de acute dolores infero-dorsal super le base del experientias in un serie total de cinquanta-cinque patientes. Le methodo es equalmente applicabile a patientes de visita e a patientes hospitalisate. Es discutite le mesuras diagnostic e le principios e le technica del administration de agentes therapeutic. Le mesuras therapeutic include le uso de Tubadil que effectua un prompte e durative alleviamento del dolorose spasmos muscular; blocage de nervo pro le interruption de impulsos dolorose; traction pelvic que promove un relaxation additional del musculos afficite; corset orthopedic pro le supporto de tessuto traumatisate; e exercitios postural pro mantener le restaurate stato del correcte function mechanic.

Como resultato de iste integrate tractamento de acute dolores infero-dorsal, le patientes ha plus curte periodos de reconvalescentia e retorna plus promptemente a remunerabile formas de labor.

14

The Iliac Apophysis: An Invaluable Sign in the Management of Scoliosis

JOSEPH C. RISSER, M.D.*

Growth and completion of growth of the body is best shown by development of the bone growth centers, epiphyses and apophyses. The ossification of the carpal bones have long been used to indicate the bone age of a child. In infancy the time of femoral head ossification is also used to determine age. A delay in development usually is associated with a delay in metabolism.

The last ossification centers to appear and develop are the iliac crest apophysis and, finally, the apophysis of the ischial tuberosity. The latter is smaller, more difficult to visualize in roentgenogram and thus is of little significance, whereas the iliac apophysis is plainly visible and has a rather long time element in its development.

An apophysis is a growing center which, as its name indicates, grows (physis) upon (apo) the mother bone. It differs from the epiphysis in that with the development of the ossification center all growth is completed

Coincident with the development of the excursion of ossification of the iliac apophysis across the iliac crest, the vertebral growth plates are completed, and spinal growth is finished. It is difficult to visualize the vertebral body growth plates and determine growth completion. Because of an almost simultaneous development of the iliac apophysis and the vertebral growth plates, vertebral growth completion can be determined by observation of the development of the iliac apophysis.

In the anteroposterior roentgenographic view of the pelvis, the iliac apophysis appears laterally and anteriorly on the crest of the ilium as an ossification center. This is termed *capping* (Fig. 1). With continued growth it develops posteriorly in its excursion of ossification across the iliac crest to dip down to contact the ilium medially at its junction near the sacrum. This is considered to be attached or *completed* (Fig. 2). When this completed ossification occurs, vertebral growth can be considered to be complete. Closure of the line between the apophysis and the ilium has no vertebral growth significance. Two or 3 years may be required for its closure.

The average time for completion of the iliac apophysis to its medial and posterior attachment is about 1 year. The shortest time was 7 months; the longest, 3 years. (Fig. 3)

The iliac apophysis may develop in fragments. After the usual capping or the appearance of ossification anteriorly and laterally on the iliac crest, further development may occur posteriorly, leaving a space, or gap, to be filled in later.

Variations in development of the iliac

* Pasadena, Calif.





FIG. 1 (*Left*). Shows the appearance of the ossification of the iliac apophysis called *capping*. It can be seen over the right side of the pelvis anteriorly.

FIG. 2 (*Right*). Shows the posterior capping of the iliac apophysis. (See arrows over the pelvis.) This boy also had a congenital anomaly at 13. He was an untreated case, followed over a period of 10 years, during which period his curve increased over 20° until completion of the iliac apophysis.



FIG 3. (*Left*) Shows a girl of 16 with an untreated curve of 30°. Her apophysis has attached with a slight interruption of the excursion across the left pelvis (See arrow.) (*Right*) Shows the girl over 15 years later. She is now a young adult. Although it has been 15 years since her last roentgenogram was taken, showing a curve of 30° and an attached iliac apophysis, her curve remained unchanged at 30°. The iliac apophysis has solidified and is now a part of the ilium. (See arrows)

apophysis may occur. Earlier development usually takes place on the iliac crest of the high side of a pelvis seen with leg-length difference. Posterior ossification of the apophysis has been seen in the occasional congenital spinal deformity and in the infantile pelvis of some polios.

The excursion of ossification of the apophysis may be short and appear to attach to the ilium at a distance one half to three quarters across the iliac crest. In these cases the initial ossification center is thicker than usual. These are termed *short excursions* (Fig. 4). Vertebral growth usually is completed with the short excursion of the apophysis.

The average chronologic age when the iliac apophysis is completed is 14 years in girls and 16 years in boys. It may occur as early as 10 or 11 years in girls and 13 or 14 in boys, and as late as 17 or 18 years in girls or 20 years in boys. Delayed development occurs in children in colder climates or in those whose metabolism is low. Early development of the apophysis occurs in warmer climates. These observations on the development of the iliac apophysis were begun in 1936 at the Los Angeles Orthopaedic Hospital and continued intensively for 10 years. The object of this study was to find some physiologic sign that would indicate the completion of vertebral growth.

From a review of 296 untreated scoliotic cases made at the New York Orthopaedic Hospital from 1926 to 1936,* it was learned that scoliotic deformity became static with completion of vertebral growth (Fig. 5). This was determined by comparison of vertical heights, standing and sitting, with measurement of the scoliotic deformity.†

In this study it was found that spinal growth was slow in the period of 5 to 10 years of age; the average increase in scoliotic deformity was 4° to 5° a year, and the increase in sitting height averaged less than ½ inch a year, whereas in the preadolescent age, 10 to 15 years, the average scoliotic increase was 10° and the average increase in sitting height was 1 inch. In cases of marked nutritional deficiency there may be a rapid increase in the scoliotic deformity, even in the slow vertebral growth years (8 to 10 years).



FIG. 4. Shows an iliac apophysis which was attached at about 75 per cent of the customary excursion. (See arrow over the left pelvis.) The curve did not increase after this attachment. This is called a short excursion of ossification of the iliac apophysis.

The relationship between vertebral growth and scoliotic deformity can be explained by Hueter-Volkmann's epiphyseal pressure rule. This states that bone growth is retarded whenever pressure is increased, and is accelerated whenever pressure is diminished. Uneven pressure is possible when joint surfaces are not parallel, as seen in the convexity of the scoliotic spine.

The vertebral growth plates are not easily visible in a roentgenogram; therefore, they did not furnish reliable information of vertebral growth. The completion of the excursion of

* Risser, J. C., and Ferguson, A. B.: Scoliosis: its prognosis, J. Bone & Joint Surg. 18:667, 1936.

† Ferguson, A. B.: South. M. J. 23:116, 1930.



FIG. 5. (*Top, left*) Girl, 11 years of age, had polio at the age of 8, with mild appearance of the lateral curvature at the dorsolumbar junction. No iliac apophysis is seen at the age of 11. (*Top, right*) At the age of 14 it is noted that the iliac apophysis is complete, and there has been a noticeable increase in the deformity. (*Bottom, left*) At the age of 18½ there has been no further increase in the deformity since the completion of the iliac apophysis. (*Bottom, right*) This is an untreated case. Also at the age of 21 there has been no appreciable increase in the deformity since the completion of her iliac apophysis. (Risser, J. C.: J.A.M.A. 164:135)

the ossification of the iliac apophysis generally was coincident with that of the vertebral growth plates. Therefore, the attachment of the iliac apophysis has proved to be an excellent physiologic sign to indicate the completion of vertebral growth.

Two hundred untreated cases examined at the Los Angeles Orthopaedic Hospital were studied as to vertical heights standing, sitting and kneeling, measurement of the scoliotic deformity and development of the excursion of ossification of the iliac apophysis across the crest of the ilium. In general, the correlation was very favorable. The sitting height was not 100 per cent accurate. Variations were noted with fatigue of the patient and the addition to sitting height by the development of the ischial apophysis and increase in buttock size in fat girls.

Ten per cent of the cases showed no increase in scoliotic deformity, even though iliac apophysis was not complete and attached. This was especially difficult to determine in those cases with a short excursion of the iliac apophysis. During the past 20 years 3 cases have been reported which showed roentgenographic evidence of an increase in the scoliotic deformity following completion, and even posteromedial attachment of the iliac apophysis. This increase in deformity continued only 3 to 6 months after the development of the apophysis and averaged 10°. The coincidental development of the vertebral growth plates and the excursion of ossification of the iliac apophysis is not 100 per cent as seen in these 3 cases. This correla-

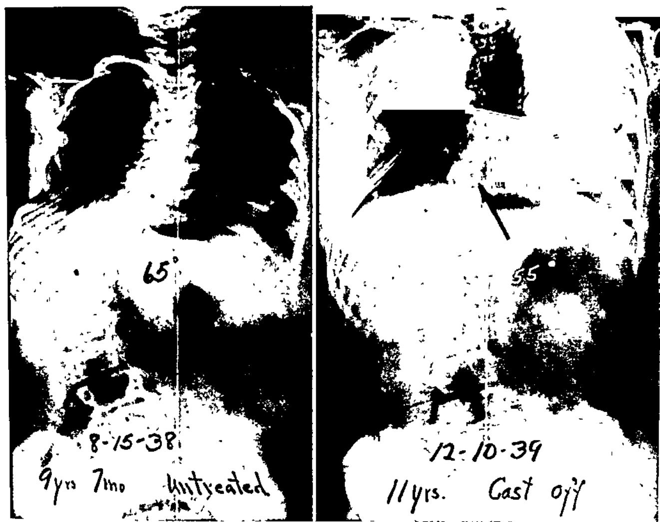


FIG. 6. (*Left*) Shows a 9-year-old girl with a severe scoliosis caused by a congenital anomaly at the eighth and the ninth dorsal vertebrae. The curve has not yet been treated. No iliac apophysis is present. (*Right*) Roentgenogram after correction and fusion of her dorsolumbar deformity. It is noted that there is a pseudarthrosis directly above the apex of the curve. The girl is 11 years old, and the iliac apophysis has not appeared. (*Continued on next page*)

tion was found in all cases, irrespective of etiology.

In the 2 years before the capping of the iliac apophysis, 75 per cent of the untreated cases increased from 10° to 35°. The deformity increases more slowly during the time when the iliac apophysis is completing its excursion. Two thirds of the untreated cases showed little appreciable increase (less than 10°) after the capping of the iliac apophysis. Any severe increase in the deformity during the excursion of the iliac apophysis was considered to be indicative of a nutritional deficiency.

It was important to use standing spinal roentgenograms for comparison. As the scoliotic grows older, flexibility decreases, even to ankylosis. Thus, the flexibility seen normally in the younger patient between standing and recumbent roentgenograms becomes less, and the recumbent deformity approaches the standing deformity. Therefore, there would be a gradual increase in the recumbent roentgenogram deformity with less and less flexibility until ankylosis was reached. At this time the recumbent deformity would have equaled the standing deformity.

Increase in the scoliotic deformity after completion of vertebral growth has been

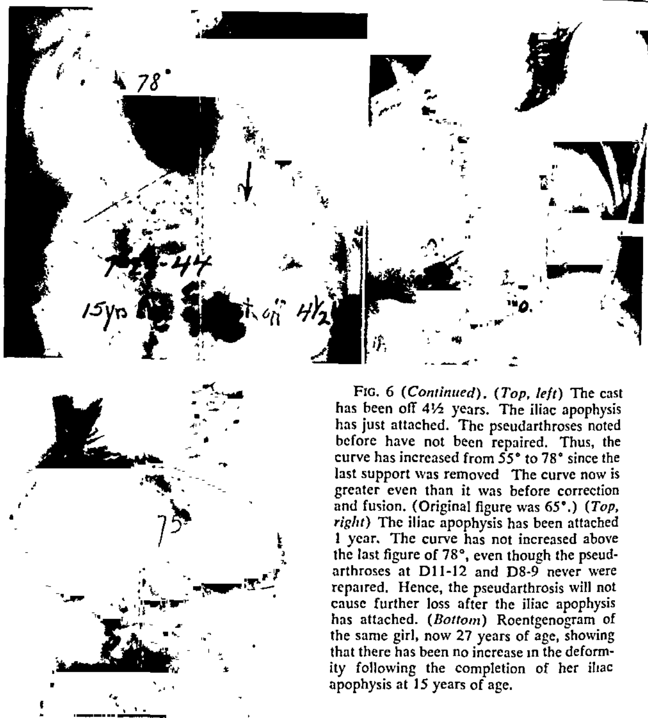


FIG. 6 (*Continued*). (*Top, left*) The cast has been off 4½ years. The iliac apophysis has just attached. The pseudarthroses noted before have not been repaired. Thus, the curve has increased from 55° to 78° since the last support was removed The curve now is greater even than it was before correction and fusion. (Original figure was 65°.) (*Top, right*) The iliac apophysis has been attached 1 year. The curve has not increased above the last figure of 78°, even though the pseudarthroses at D11-12 and D8-9 never were repaired. Hence, the pseudarthrosis will not cause further loss after the iliac apophysis has attached. (*Bottom*) Roentgenogram of the same girl, now 27 years of age, showing that there has been no increase in the deformity following the completion of her iliac apophysis at 15 years of age.

seen in very few cases. Superimposed pathology, such as marked osteoporosis, degenerative arthritis or disk degeneration, may allow *an increase of lateral curvature*. Compression fracture of an apical vertebra has caused an increase in the curvature of the spine.

Utilization of the development of the iliac apophysis as a guide to the progress of spinal growth and of the lateral curvature is of the greatest importance. In the management of scoliosis, no treatment to prevent an increase in the lateral curve is needed for the individual whose roentgenograms show *an attached iliac apophysis. Conversely, the* patient who has no visible iliac apophysis will require cast correction, surgical immobilization, or both, to prevent increasing deformity.

In a certain number of cases surgically treated, the fusion may not be solid, or it may not be long enough to cover the area



FIG. 7. (*Top, left*) A girl, 16 years old, whose iliac apophysis already is attached and is almost solid. Her lateral curve measures 54°. She has had no treatment. (*Top, right*) Her semibent jacket has just been removed, 8 months after surgical fusion had been accomplished from D4-L2. The maximum correction obtained in the turnbuckle jacket was from 54°,to 22°. Already there has been a small loss of correction of 8° (22°-30°). A pseudarthrosis at D10-11 is noted. (*Bottom, left*) Lateral view of the spine. In this view the pseudarthrosis at D-10 and 11 can be seen. (See arrow.) (*Bottom, center*) Two years after the cast was removed, showing a deformity of 46°. There was a loss of correction at the point of the pseudarthrosis immediately after the cast was removed, but there was no further loss, as indicated by this roentgenogram, taken 2 years after the cast was off. The iliac apophysis being completed, there was no further growth and, therefore, no further propensity for increasing deformity, even through the pseudarthrosis. (*Bottom, right*) Two years later without any further loss of correction, because there has been no further growth.



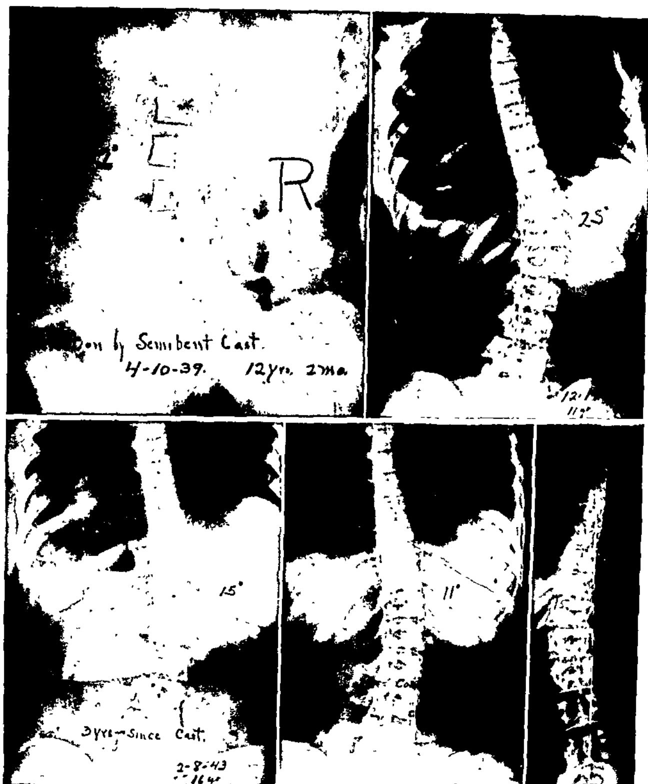


FIG. 8. (*Top, left*) An 11-year-old girl with 25° dorsolumbar curve. No iliac apophysis showing. She was corrected with a semibent antigravity cast, giving 12° of overcorrection. (*Top, right*) Shows the girl in a semibent jacket with the curve bent against itself. The curve has been reduced from 25° to 12° to the opposite side. The iliac apophysis is well capped (*Bottom, left*) Three years after cast. (*Bottom, center*) Six years after cast (*Bottom, right*) Roentgenogram taken 18 years later shows that the patient is maintaining her correction at 15°, making a total of 10° maintenance of correction during the past 20 years. The lesson to be gained is that the iliac apophysis completion was a guide as to when the cast should be removed in those cases in which correction was maintained only by the cast and not by fusion. (Risser, J. C.: Am. Acad. Orthop. Surgeons Instructional Course Lectures 14:91, Ann Arbor, Edwards)

of deformity (Figs. 6 & 7). In these cases, if the individual has not completed vertebral growth, there will be an increase in the lateral curve, even beyond its original deformity. But if the patient is through growing, as shown by the attachment of the iliac apophysis, there will be the initial loss of part or all of the correction. But this loss will not cause the deformity to increase beyond its original curvature. Thus, during the growing years, repair of the pseudarthrosis or additional fusion as indicated is imperative to prevent an increasing deformity.

In the occasional use of the localizer cast without surgery to prevent an increase in the lateral curve, it is important to know when the cast can be safely discarded (Fig. 8). The attachment of the iliac apophysis is used as a criterion. If the growth center has completed its excursion of ossification, then it is safe to conclude that the cast treatment, for growth of the spine and of the lateral curve, can be stopped. But if the cast is removed before the iliac apophysis has attached, then we may expect a return of the deformity and an increase in the deformity in proportion to the anticipated spinal growth.

The significance of the iliac apophyses lies in its use as a more accurate criterion for the completion of vertebral growth and for the progress of the spinal curvature. Moreover, it is an invaluable aid that could be used widely in determining those patients whose deformity will remain static and, therefore, do not need preventative treatment. The patient could be told that the attachment of the iliac apophysis indicates the end of increase in his deformity. This information should save the patient needless worry and a considerable expenditure for unnecessary treatment.

Le Apophyse del Ilio: Un Importantissime Guida in le Tractamento de Scoliosis

Summario in Interlingua

Depost plure annos on ha recognoscite que le deformitate scoliotic deveni static con le completion del crescentia vertebral. Infelicemente, il esseva difficile determinar accuratemente si o non le crescentia vertebral habeva cessate.

In le curso del passate decennio, un grande numero de casos — tanto tractate como etiam non-tractate—esseva examinate con respecto al relation del sequente tres factores: (1) Le severitate del deformation. (2) Le clinic grandor vertical (a) in position erecte, (b) in genuflexion, e (c) sedente. E (3) le excursion del ossification in le apophyse del ilio.

Le datos colligite suffice a concluder que, quando le apophyse del ilio ha completate su excursion de ossification ab le cresta in basso e es attachate al linea postero-central de ille osso, le crescentia vertebral es complete e le deformitate scoliotic ha devenite static.

Iste constatation es importantissime pro plure rationes. (1) Illo permitte un intelligente disposition del casos de scoliosis, viste que post le completion del crescentia nulle tractamento es requirite pro prevenir un augmentation del deformitate. (2) Il seque que le tractamento a corset de correction pote esser terminate sin risco si tosto que le crescentia del scoliotico es complete. E (3) il deveni clar que un pseudoarthrosis in un scoliotico qui ha completate su crescentia pote esser considerate como inactive, durante que le mesme pseudoarthrosis in un scoliotico qui cresce ancora merita esser reparate.

15

An Anatomic Evaluation of Whiplash Injuries*

PETER B. WRIGHT, M.D., AND LOUIS P. BRADY, M.D.

The term *whiplash injury* covers a multitude of diagnostic sins, as did the term *indigestion* thirty-odd years ago. However, we believe that whiplash is with us for a long time, since it has come to signify something that the patient thinks he understands and that lawyers relish, and doctors have become so accustomed to it that they employ the term, even though in a broad sense.

The mechanism of these injuries has been described so adequately that it will not be reiterated here. It is sufficient to recall that unexpected, forceful excursions of the neck result in an abnormal degree of motion in one or more of the 6 anatomic directions which, when carried beyond natural limits, cause structural damage in direct ratio to the violence.

When, in spite of therapy for all possible underlying pathology, symptoms persist, sometimes become more severe and, too often, change to a completely new pattern, the doctor is confronted with a perplexing situation

A real problem exists when sufficient time for recovery has elapsed after an accident and the patient's complaints and disability persist. In such case, of necessity we must begin a complete review of the patient, his attitude, possible extenuating circumstances, personal stamina, impending litigation, compensation problems, etc., and the very important psychological structure of the affected individual as well as his actual physical disorders.

Injuries to the neck region which are not severe enough to cause gross damage may, nevertheless, have caused a mild cerebral concussion. This, in turn, could produce circulatory disturbances sufficient to add to, if not cause, the so-called *psychological overlay*. The existing worry of litigation or "compensation doubts" can be aggravating factors and further cloud the clinical picture. The fact that the autonomic nervous system may also be injured will explain why some of these patients develop gastro-intestinal disorders, peptic ulcers, spastic colitis, chronic constipation, etc. Glandular disturbances can also be reasoned out along this same line, i.e., post-traumatic diabetes.

Since cases in this category often become chronic, pitiful and annoying, we must make an early analysis of the whole situation, provide an adequate diagnosis and institute proper treatment. This is most essential if we expect to avoid secondary complications which may be physical or psychological, or both

Of considerable interest was a report by the neurosurgeons of the University of Tennessee who surveyed 100 patients with previously diagnosed cervical neck strains following automobile accidents whose litigation or compensation claims had been settled. They found that after the legal claims were settled 88 per cent showed complete recovery; 12 per cent continued to have symp-

* Jewett Wright Orthopaedic Clinic, Orlando, Fla.

toms; only 6 per cent had a continuation of medical care. Therefore, it is quite evident that there is a rather marked psychological overlay in a good many of these cases, and we should always keep this fact in mind.

Knowing of the approaching court trial, where much will hinge on the doctor's testimony, the patient, although not malingering, will magnify his symptoms in an effort to strengthen his claim. Psychoneuroses must be recognized, because surgery in these cases offers little toward cure and may well cause exaggeration of the symptoms. It behooves us, therefore, to consider the patient in a serious light from the very beginning if we hope to prevent the many possible sequelae.

The anatomic structures which are exposed to damage in these mishaps may be listed as follows (the order is purely arbitrary on our part, and no definite reference is made to frequency, vulnerability or severity):

The skin, being pain sensitive, will cause symptoms when damaged. Cuts, contusions, abrasions, abrasive burns, are the usual injuries.

Subcutaneous fat and the superficial fascia are practically insensitive to pain and, although injured, usually produce no symptoms other than swelling, due to edema or the extravasation of blood.

The deep fascia (Fig. 1) is sensitive to pain. It is penetrated by motor, sensory and autonomic nerves, and is innervated by the sensory ones. Damage to this structure can produce many and varied symptoms and symptom complexes. Not only is this due to the sensory innervation but also to the expanse of this structure. The deep cervical fascia surrounds muscles, blood vessels and nerves, forming sheaths for each, and connects these structures one to the other in such a way as to render the deep fascia extremely important, not only from the standpoint of surgery but also because its many transitions may well suffer injury when the deep fascia is torn or overstretched.

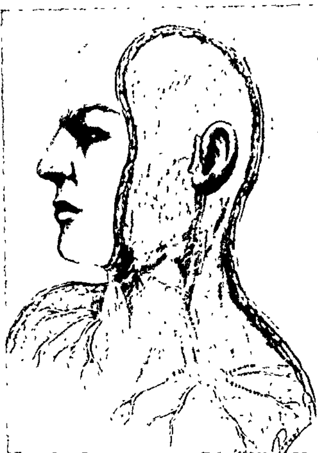


Fig. 1. A diagrammatic sketch showing the continuity of the deep cervical fascia with the cranial, pectoral, deltoid and posterior fasciae; also, the manner in which the nerves penetrate the fascia and how the fascia receives its innervation. This demonstrates further why tearing, stretching or scarring of the deep fascia will produce pain and symptoms.

Above, the deep cervical fascia is so continuous with that of the head that the two should be considered as one. The investing layer of the two sides blend together across the mid-line. It splits to form the sheaths, as that of the sternocleidomastoid muscle in front and the trapezius muscle posteriorly. Also anteriorly it forms the pectoral fascia, which in turn blends with the fascial covering of the rectus abdominus.

Laterally, the deep cervical fascia (Fig. 2) is continuous with the deltoid fascia, the inferior portion of which becomes the axillary fascia and the axillary sheath which envelops the large vessels and nerves of the upper extremity. Not only is the deep cervi-

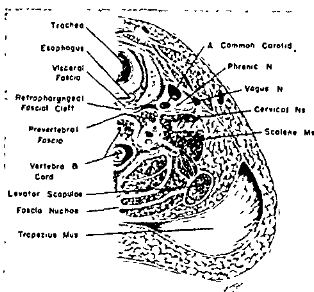


FIG. 2. Cross section through lower portion of the neck. The deep cervical fascia envelops muscles, nerves, blood vessels and visceral structures, forming sheaths, but it is so continuous that contracture and fibrosis of one area may be transmitted to others.

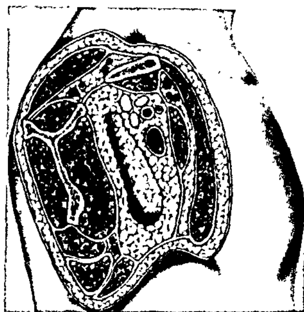


FIG. 3. Sagittal section showing how the pectoral fascia and the axillary fascia are continuous and encircle the brachial plexus and the axillary artery before extending farther laterally to join the axillary sheath, which envelops the large vessels and nerves of the upper extremity.

cal fascia continuous from above downward, but it forms circumferential coverings for all structures as seen on cross section. (Fig. 3)

It is to be noted that the deep fascia blends (Fig. 4) to help form the fascia nuchae, which in turn is intimately related to the cervical interspinous ligaments that exist from the occiput to the lumbodorsal fascia. In turn, it is a well-recognized anatomic fact that the iliotibial band is, to all intents and purposes, a continuation from the lumbodorsal fascia.

From this anatomic fact it is not beyond the realms of possibility to have a low back fascial injury from a primary hyperexcursion of the cervical region. True enough, a patient *with a primary cervical injury often,* a few days later, will begin to complain of pain in the low back, with sensitive trigger points in the fascial region as demonstrated by light palpation.

In the neck, injury to any one portion of the deep cervical fascia may also affect any of its ramifications.

Skeletal muscle has no sensation of pain by direct trauma. However, ischemia, stretching and contact with hypertonic solutions cause pain. Therefore, concentration of lactic acid in fatigued muscles causes pain, as will lack of blood supply or constant overstretching. Spasticity of muscles over long periods of time results in contractures and loss of normal muscle balance. Secondary to muscle contracture are joint immobility and disuse arthritis. Stretching contracted muscles causes pain, as does stretching flexed and fibrosed joints.

Hemorrhage into muscle may produce radiating pain; for example, hemorrhage into the sternocleidomastoid muscle will result in *neuralgic pains within the distribution of the* lesser occipital and the greater auricular nerves. Contusion, overstretching or tearing of muscle, fascia or ligaments, will produce congestion and edema with resulting pain

Should a contracted and fibrosed scalenus anterior muscle (Fig. 5) be divided together with its sheath, the subclavian artery is relieved of its compression; likewise, if the

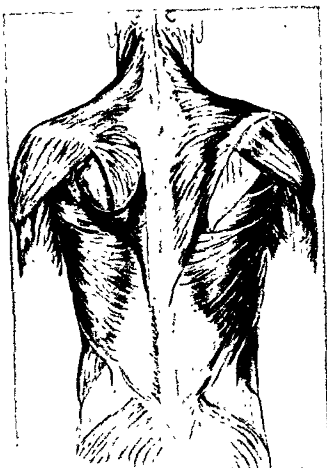


FIG. 4. The fascia nuchae blends into the ligamentum nuchae and the interspinal ligaments, all of which are continuous and become intimately related to the lumbodorsal fascia.

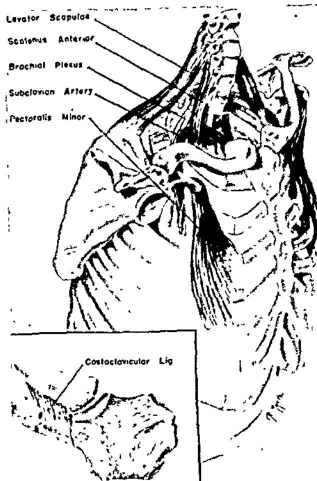


FIG. 5. Diagrammatic drawing demonstrating the relation of the brachial plexus and the subclavian artery to the scalenus anterior muscle; also the anatomic arrangement of the anterior scalene, the pectoralis minor and the levator scapulae muscles. Inset depicts the ligamentous connection of the first rib and clavicle.

fascia is further divided, the brachial plexus is freed of the pull that is placed upon it by tension on the fascia. However, this division may result in a muscle imbalance and an increased downward pull of the coracoid process by the pectoralis minor muscle and lifting of the medial angle of the scapula by the levator scapulae, causing further tension of the deep fascia. Therefore, it may be necessary in these cases either to resect a portion of the first rib or to divide the pectoralis minor in order to restore balance.

Tendons and the tendon sheath are subject to injury, and there may be resulting painful tenosynovitis, the degree of which depends on the character and the violence of the trauma and the anatomic location of the tendon. Tendons may be avulsed from their insertions or at the musculotendinous junction, resulting in fibrosis at the site of the injury.

The periosteum is pain sensitive. Subperiosteal hemorrhage is quite painful. If the periosteum is torn, myositis ossificans is likely to result. Exostoses due to trauma also may result and be the cause of pressure on certain structures.

Cortical bone is not pain sensitive, neither is the marrow, but cancellous bone is quite vascular and well innervated. The vertebral bodies are good examples.

The articular cartilage of the normal joint

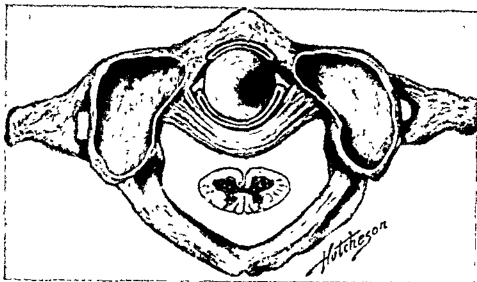


Fig. 6. Showing relation of the odontoid process and atlas, the transverse ligament of the atlas and the synovial membrane.

is not sensitive to pain. The joint, as a whole, may be painful due to the sensitiveness of the ligaments, the capsule and the synovial membrane. Traumatized joints are prone to develop hypertrophic changes, such as hypertrophic arthritis with spurring.

Torsion, pressure and needling of blood vessels will produce pain; therefore, it may be considered that blood vessels are pain sensitive. Blood vessels may be contused by trauma, with a resulting thrombosis, which, in turn, causes ischemia of the supplied area and symptoms of ischemic pain.

Nerve trunks are subject to pressure, edema, stretching and torsion, as well as direct trauma. Pain may be transmitted from the nerve endings or originate in the trunk at the site of pressure or trauma and then be radiated along the path of the nerve.

The cervical disk syndrome, in our experience, is quite uncommon, but it has been estimated that approximately 10 per cent of all disk lesions occur in the cervical region. However, it is interesting to note that these lesions rarely are seen under the age of 40 and usually in persons from 40 to 60 years of age. The clinical picture generally is sufficient for diagnosis and localization of the lesion, but when there is doubt a myelogram may be performed, as in the cervical region this is quite accurate. The protrusion may be lateral and give root symptoms, but it may be central and give cord symptoms.

Individuals in the fourth decade of life and older almost invariably have some hypertrophic arthritic changes, and it must be stressed that the hypertrophic process may be exaggerated by the trauma. Spurs

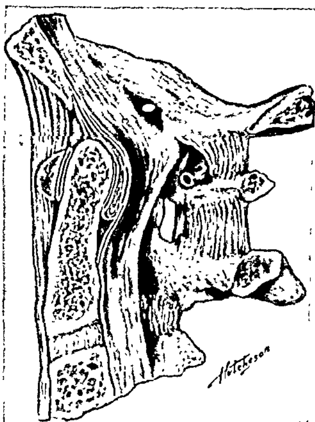


Fig. 7. Relations of odontoid process and atlas seen on sagittal section The [illegible]

winds round the superior articular process of the atlas. This allows more mobility without damage to the artery.

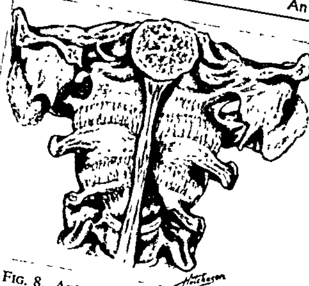


FIG. 8. Anterior longitudinal ligament, the antero-atlanto-occipital membrane, the antero-atlanto-axial ligament.

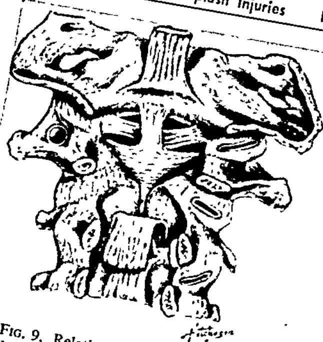


FIG. 9. Relation of membrane tectoria and the posterior longitudinal ligament. Membrane reflected to show deeper relation of transverse ligament of the atlas.

may be detached, and resulting reactions will be responsible for the pain and symptoms. Nerve root pain may be due to foraminal narrowing, and surgical unroofing may be necessary.

There may be any degree of fracture of the vertebral bodies, from complete compression to slight lipping (Fig. 6). The neural arch may be fractured, or, in the case of the epistropheus or axis, the odontoid process may be fractured (Fig. 7). In these cases, if there is survival, the fractures heal with proper splinting, and, in our opinion, surgery is indicated only rarely and then for relief of cord pressure and other soft-tissue injuries.

Fractures of the cervical spinous processes are quite rare. Roentgenographic demonstration of cervical spine fractures often is very difficult, and in the face of continuous unexplained complaints the roentgenograms should be made repeatedly from all possible angles

Luxations and subluxations of the articular facets may occur. There may be more cord damage than the roentgenogram would indicate, as at the time of injury there may be more excursion than can be demonstrated because there often is a secondary rebound and tendency to return to normal relations if obstructions do not prevent this.

The facet syndrome (Fig. 8) may indicate (1) torn ligaments and/or capsule, (2) injury to articular cartilage or (3) fracture. Torn posterior ligaments permit forward

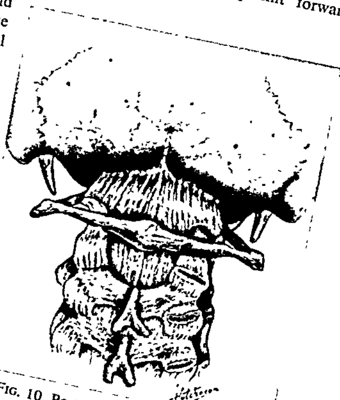


FIG. 10. Postero-atlanto-occipital membrane, postero-atlanto-axial membrane, capsular ligaments and articular capsules.

subluxation, while tearing of the anterior ligaments permits posterior excursion. These *subluxations may be unilateral or bilateral* (Fig. 9). The peripheral and the autonomic nerves have to penetrate the posterior ligaments to gain exit and are subject to damage when these ligaments are injured (Fig. 10).

Nerve injury may vary from avulsion from the cord to tearing of the plexus, to overstretching of the nerve trunk, to compression by soft tissues or bone. The nerves involved as they pass through the intervertebral foramina may be motor, sensory or autonomic.

The early or immediate symptoms following an accident are rather characteristic. Usually, the patient is either dazed or rendered momentarily unconscious, complains of vertigo, blurred vision, pain and stiffness *in the neck region, headache (usually occipital)*, pain or tingling in one or sometimes both upper extremities, nausea and often apprehension.

The late and later symptoms are bizarre and multifarious, changing in style and pattern, and often there is a concomitant feeling of anxiety on the part of the patient. Not too infrequently, we see patients with these *manifestations who give no history of a* specific injury. Repeated mild traumata experienced in certain occupations can be causative factors.

One should be slow to adjudge a patient neurotic or psychoneurotic; there must be a firm foundation for such a verdict.

*The anxiety may be due to central nerv*ous system or autonomic nervous system damage, to individual peculiarity, to persuasive influences, to aping other patients or to malingering. Each anatomic structure which may have received some of the injury should be given due consideration, and not *until then can one incriminate or eliminate that* structure as a source of symptoms.

The treatment of the immediate or early symptoms is directed toward giving relief of pain and making the patient comfortable. At this time, to reassure the patient will be of great value in gaining his confidence and co-operation. Every effort should be made *to prevent the patient from re-enacting the* accident.

Muscle spasm can best be treated by mild heat, gentle massage and very gentle traction.

When traction is utilized, we must be as nearly certain as possible which structures have been injured. Traction with hyperextension is contraindicated when the prevertebral or the visceral fasciae have been torn and the retropharyngeal fascial cleft is distended with blood from hemorrhage (Fig 11). Patients with such an injury will complain of difficulty in swallowing. A swelling behind the posterior pharyngeal wall either can be seen or palpated. Traction with *hyperextension is also contraindicated* when there is injury to the posterior vertebral elements with resulting narrowing of the intervertebral foramina. Traction with hyperextension is contraindicated when there is tightness from extravasation of blood into the fleshy portion of the scalene or the *sternocleidomastoid muscles, or when in*creased tension exists within the fascial *sheath from hyperemia or edema*. Traction with the neck straight, or slightly flexed, is safe and usually gives relief. Spastic muscles relax with continuous traction. This traction should exert only enough pull not only to ensure relaxation but also to prevent muscle contractures and furnish adequate *immobilization.*

Traction is also important in ligamentous injuries, as it prevents shortening of these structures and may well obviate surgery at a later date. Pain, due to a hypertrophic arthritic cervical spine, frequently can be *relieved with traction.*

Treatment of residual symptoms requires considerable diagnostic study to pinpoint the underlying pathology. If surgery is performed and the symptoms persist postoperatively, the psychological overlay will be markedly exaggerated. Surgery should be

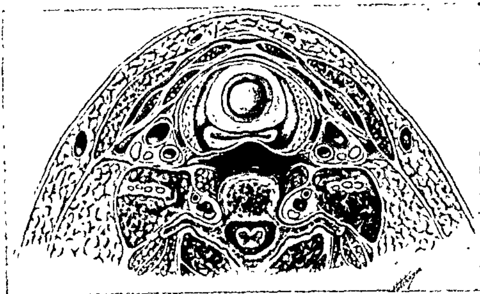


Fig. 11. Distention of retropharyngeal fascial cleft with hemorrhage following tearing of prevertebral fascia.

delayed until all reasonable conservative treatment has failed and then undertaken only upon a well-founded diagnosis.

The following case histories will exhibit a variety of the chronic problems which we have encountered and treated:

Mrs. P. B. L., aged 44 years. This housewife and seamstress began having pain, without antecedent trauma, in the right upper extremity that gradually increased in severity until it involved the entire right upper extremity and was aggravated by any activity. She was seen by a series of doctors and at one time or another was diagnosed as having bursitis, neuritis, myositis and arthritis, and was given various forms of medication, including injections of hydrocortisone acetate into the joints, diathermy, ultra sound, etc. All roentgenograms were essentially negative.

On examination we found her to be exquisitely tender in the posterior triangle of the neck on the right side; pressure here reproduced her pain with radiation into the right upper extremity. Sensation was normal, and the reflexes were normal However, the hand was extremely weak. Bending her head to the right would relieve the pain somewhat; in the opposite direction the pain was increased.

After a short period of conservative treatment, a scalenotomy and fasciectomy of the involved portion of the deep fascia were carried out on the right side. The patient had some immediate relief from her pain, however, it was approximately 2 weeks before she became essentially asymptomatic and began regaining the strength in her hand. On her last visit 4 months postoperatively, she stated that the pain was practically gone. She had returned to work and was quite pleased with the result.

Mrs. C. C., aged 53. This widow, who was working as a cleanup woman at a local drive-in, complained of pain and aches in her left shoulder and neck 2 months prior to her original examination. She did not recall any specific injury. The pain had increased gradually in severity, and, at the time of the examination, to turn the head would radiate pain into the suboccipital region and behind her ear, as well as into the left shoulder and the left upper extremity.

Examination revealed a well-developed, well-nourished white female complaining of pain in the left side of her neck, shoulder and arm with radiation of pain into the mastoid region and the occipital region. She was extremely sensitive at the base of the neck in the posterior triangle. There was some radiation of pain into the left upper extremity, which was colder and somewhat cyanotic. There was a 20-mm. difference in systolic pressure in the two extremities, the left being lower than the right. Pressure over the subclavian artery duplicated her symptoms exactly. After 1 month of conservative treatment in the form of traction, diathermy and massage, she was admitted to the hospital, and the subclavian and the carotid arteries were stripped of dense fascia.

Considerable adhesions were found about the carotid artery. On first exposing the fascia covering this vessel, no pulsation whatsoever was visible. However, after the sheath had been stripped, a definite pulsation immediately became apparent. The scalenus anterior muscle, which was tight, was divided; this released the subclavian artery, which also was quite constricted.

Postoperatively she had complete relief of

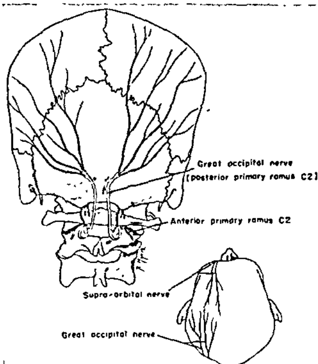


FIG. 12. Diagrammatic drawing of the exit of the second cervical nerve. The great occipital nerve loops round the articular facets and rests on the vertebral arches of the axis. It is in a vulnerable position and is not protected by an intervertebral foramen.

symptoms, and the postoperative course was smooth. At the time of her last visit, which was approximately 4 months postoperatively, she was essentially asymptomatic and doing well.

Mr. C. M. D., aged 26. This white recreation director for the city gave a history of having had [illegible]

view of his occupation. He was given the usual form of conservative treatment, which temporarily was helpful. On first being seen by us in 1952, approximately 1 year after his symptoms began, he responded to conservative treatment in the form of local nerve blocks.

He was seen again 4 years later, this time with a history of having had surgery 1 year previously because of a continuation of the pain. Apparently a scalenotomy had been carried out on the right This had not relieved the symptoms whatsoever He was given conservative treatment by us for several weeks, however, because of his continued complaints and lack of improvement a posterior cervical fasciectomy was carried out with removal of the ligamentum nuchae and the upper 4 dorsal interspinous ligaments.

Postoperatively the patient was completely relieved of the symptoms in the back of his neck and shoulders; however, he continued to complain of pain in the posterior triangle on the right with radiation down the right upper extremity. He was again admitted to the hospital 2 months from the time of his first surgery, and the brachial plexus was explored. Considerable dense, fibrous adhesions were found overlying the deep cervical fascia; these were resected, and the brachial plexus was thoroughly explored and freed. No other pathology was found. The scalenus anticus had been divided.

It is now a month since the patient underwent surgery, and he is completely asymptomatic Since this is the first relief that he has had in 6 years, we feel that a good end-result can be expected.

J. S., aged 25. This unemployed white woman was referred to us by a chiropractor because of pain in the mid-dorsal and the left scapular region of some 6 years' duration with no other history of injury. She had many complaints referable to this area as well as difficulty in swallowing, but primarily her pain was in the left side of the neck anteriorly and posteriorly, as well as in the left shoulder.

On examination it was noted that the color of the 2 hands was different. The left looked fairly blanched. She was found to be exquisitely tender over the posterior triangle of the neck on the left, and compression of the subclavian artery reproduced a good deal of her pain. She was also tender over the greater occipital nerve on the left. Traction at the time of the examination seemed to relieve some of her pain; pressure over the occiput did not increase it. After 1 month's trial of conservative treatment, which brought no relief, she was admitted to the hospital and a fasciectomy and scalenotomy were carried out on the left. The pulsation in the subclavian artery was noted to be normal following this, and the brachial plexus was explored and freed of adhesions.

Immediately following surgery the subclavian pulsation was noted to be better. The color of the extremity also had improved The postoperative course was smooth, and clinically she was much better.

It is now 3 months since operation, and the patient has approximately 90 per cent relief of pain, which we feel will diminish gradually with physiotherapy and symptomatic care.

Mr. J. S. D., aged 47 (Fig. 12). This white male was injured when he fell from a 7-foot platform. He fell on his side and sustained injuries

to the entire left side of his body, including his neck. He was not seen by us until 3 weeks after injury. Then he complained of limitation of motion of the entire cervical spine and pain over all the paravertebral muscles and in the ligamentum nuchae. Neurologic examination was negative, and roentgenograms showed no evidence of any bone or joint abnormalities.

The patient was treated conservatively for 9 months, during which time he received nearly every form of physiotherapy, neck immobilization, muscle relaxants, etc., including B_{12} and multiple vitamins—all to no avail. He continued to complain of severe pain, primarily over the greater occipital nerve on the right, and would get approximately 2 to 3 days' complete relief of pain from a local infiltration of this area with a long-acting anesthetic agent. Nine months after injury he was admitted to a local hospital, and the greater occipital nerve was resected for approximately 1½ inches. Postoperatively the patient was relieved completely of all pain. He had an uneventful recovery and was about ready for discharge when he was involved in another accident, this time in his automobile. Shortly afterward the symptomatology in his neck returned, this time on the left, and after a prolonged period of conservative treatment, again with no relief of symptoms, he was readmitted to the hospital and the great occipital nerve on the left was resected in the same manner as on the right.

Postoperatively he was completely asymptomatic. The large area of sensory loss secondary to this surgery has not proved to be disagreeable to the patient, and there have been no sequelae of significance secondary to this area of anesthesia

SUMMARY

Although many different structures may receive damage, the intricacies of the deep fascia must be remembered. From our experience, we have come to feel that the deep fascia is the structure injured most frequently and one that can cause the greater variety of symptoms.

We should like to emphasize the fact that similar symptoms and effects have been found in patients who can give no history of an injury. In our practice the repeated mild traumata of certain occupations have produced the same clinical picture as well as the same surgical findings.

It is difficult to pinpoint the location of the injury, but usually this can be done with perseverance. The majority of those who cannot be accurately diagnosed clinically will be found to be involved in litigation, having compensation difficulties, or to be malingering.

In our opinion, conservative treatment should be given over a reasonable period of time before surgery is decided upon. The only exceptions should be those in which diagnosis can readily be made and the damage can be corrected only by surgery.

BIBLIOGRAPHY

Allen, W. L.: Introduction, Internat. Rec. Med. 169:1, 1956.

Berryman, Sloan, Jr.: Diagnosis of whiplash injuries, Internat. Rec. Med. 169:26, 1956.

Billig, H. E., Jr.: Traumatic neck, head, eye syndrome, J. Internat. Coll. Surgeons 20:558, 1953.

———: The mechanism of whiplash injuries, Internat. Rec. Med 169:3, 1956.

Compere, E. L.: Personal correspondence.

Davis, Arthur G.: Injuries of the cervical spine, J.A.M.A. 127:149, 1945.

Dittrich, R. J.: The latissimus dorsi syndrome, Ohio M. J. 51:973, 1955.

Fields, Albert: The autonomic nervous system in whiplash injuries, Internat. Rec. Med. 169:8, 1956.

Gay, J. R., and Abbott, K. H : Common whiplash injuries of the neck, J.A.M.A. 152:1698, 1953.

Gershon-Cohen, J., Budin, Earl, and Gauser, Frank: Whiplash fractures of the cervicodorsal spinous processes; resemblance to shoveler's fracture, J.A.M.A. 155:560, 1954.

Gotten, Nicholas: Survey of 100 cases of whiplash injury after settlement of litigation, J.A.M A. 162:865-867, 1956.

Gundrum, L. K.: Whiplash injuries to the ear, Internat. Rec. Med. 169:21, 1956.

Hillman, J. W., and Regen, E. M.: Injuries of the cervical spine, J. Tennessee M. A. 47:147, 1954.

Hunter, C. R., and Mayfield, F. H.: Role of the upper cervical roots in the production of pain in the head, Am. J. Surg. 78:743-751, 1949.

James, O E., Jr., and Hamel, H. A.: Whiplash injuries of the neck, Missouri Med. 52:423, 1955.

Lipow, E. G.: Whiplash injuries, South. M. J. 48:1304, 1955.
Lord, J. W., Jr.: Diagnostic and surgical aspects of the shoulder girdle syndromes, New York J. Med. 55:2021, 1955.
McIntire, R. T.: Internat. Rec. Med. 169:2, 1956.
McKeever, D. C.: Personal correspondence.
Mathewson, J. H.: Dynamics of car crashes, Internat. Rec. Med. 169:29, 1956.
Michele, A. A.: Scapulocostal syndrome: its mechanism and diagnosis, New York J. Med. 55:2485, 1955.
Middleton, J. M.: Ophthalmic aspects of whiplash injuries, Internat. Rec. Med. 169:19, 1956.
Morehouse, L. E.: Body functions and controls in whiplash injuries, Internat. Rec. Med. 169:11, 1956.
Morrow, James: Surgical anatomy of whiplash injuries, Internat. Rec. Med. 169:14, 1956.
Nicholson, J. T., and Armour, W. S : Recognition and treatment of cervical spine injuries, S. Clin. North America 33:1571, 1953.
Overstreet, J. W., and Ochsner, A.: Traumatic rupture of the esophagus, J. Thoracic Surg 30:164, 1955.
Reichert, F. L.: Atypical neuralgias of the head; headaches, so-called migraine and complications of whiplash injuries and other cervical trauma, Am. J. Surg. 89:1203, 1955.
Schaefer, J. H.: Whiplash injuries of the neck, J.A.M.A. 153:974, 1953.
———: Importance of whiplash injury, Internat. Rec. Med. 169:28, 1956.
Toone, E. C., Jr., and Kawchak, J.: Painful nonarthritic disturbances of the hand and wrist, Virginia M. Month. 82:441, 1955.

Un Evalutation Anatomic de "Vulneres a Colpo de Flagello"

Summario in Interlingua

Le termino *whiplash injury* (i.e., vulnere a colpo de flagello), que ha trovate acceptation general in le usage anglese como designation de vulneres resultante de inexpectate e violente excursiones del collo, non representa un entitate definite. In isto illo es comparabile al termino *indigestion* que etiam coperi un vaste campo de significationes.

Le vulneres structural que resulta de un subite e violente excursion del collo depende in lor grado de serietate directemente ab le fortia del excursion

Un ver problema se presenta quando depost le accidente un sufficiente intervallo de tempore ha passate pro le effectuation del restablimento del patiente sin que iste se ha emancipate ab persistente gravamines e invaliditate In tal casos il es imperative facer un complete examine de omne le pertinente datos physic e psychic, con attention prestate al facto que le existentia de lesiones del systema nervose central o autonome es etiam un possibilitate.

Un prompte e definite diagnose sequite per le appropriate tractamento es del prime urgentia, proque multes de iste casos deveni chronic e disveloppa complicationes psychologic. Il existe le forte tendentia del parte del patiente de exaggerar su symptomas, ben que isto non significa que le patiente es un simulator. Interventiones chirurgic a iste tempore es clarmente contraindicate. Litigation es un factor de multe influentia, e a vices il es impossibile pronunciar le patiente curate ante le resolution del processo juridic.

Es discutite le structuras que es exponite a vulneration in iste casos. Le fascia profunde es vulnerabile. Viste que illo es penetrate per nervos motori, sensori, e autonome, su vulneration resulta in multiple symptomas e varie complexos de symptomas. Grande attention es prestate in le presente reporto al structura anatomic e al ramificationes del fascia profunde.

Es etiam describite lesiones muscular insimul con le complicationes que es le plus probabile.

Lesiones de osso, periostea, e cartilagine articular es frequente e se manifesta in varie symptomas.

Vulneres de vasos e nervos es describite. Le complicationes possibile es enumerate.

Le syndrome del disco cervical es describite, insimul con le fracturas, subluxationes, e luxationes que pote occurrer in association con illo. Le syndrome del facietta es describite, e complicationes possibile de illo es mentionate.

Es delineate le diagnose e le tractamento de casos vidite in lor prime stadios.

Es presentate cinque casos chronic e obstinate que esseva tractate per intervention chirurgic.

16

The Role of the Orthopaedic Surgeon in the Management of Cerebral Palsy

S. RALPH TERHUNE, M.D., PAUL W. SHANNON, M.D.,
FRED H. DEVANE, M.D., AND J. CARTER DENTON, M.D.*

Some time ago a healthy infant in our hospital had 6 beautiful and good-functioning fingers on each hand and could play in a remarkable manner an 8-oz. nursing bottle from base to tip with either or both hands. However, the child's parents wanted these hands to look like all other hands; therefore, we performed a surgical limitation procedure. Now the hands function no better than anyone else's, *but they conform to the* general pattern of hands.

Twenty-five years ago little spastic Tony could walk unaided with a scissors gait. His father brought him to the clinic "to get his legs fixed." In due time following adductor tenotomies and nerve sections, Tony was free of the scissors gait and his legs looked so much better and straighter. But Tony was not able to take a single step without crutches after the operation.

Nine-year-old Joe walked with a rigid spastic equinus foot. The foot was fixed, and it looked well, but Joe started having convulsive seizures on the first night after operation, and he was still having them 3 and 4 times a day when we last saw him, 17 months after operation.

Eddie, a 16-year-old spastic paraplegic, could sit erect in his chair with rigid flexion contractures at hips and knees. His legs were straightened with traction and surgical section of the hip and the knee flexors. In due time he could lie comfortably in bed with straight, good-looking lower extremities. Now he is transformed; he is bedridden and cannot sit in a chair any more.

John is a spastic moron. In his 10th year he fell from a tree limb and landed on his *head, injuring his brain.* When he was 16, one of his equinovarus feet was straightened by means of a soft-tissue release operation and the application of a cast and, later, a shoe and brace. At 17, the brace was discontinued because he was acquiring pressure ulceration on the lateral side of his ankle as the foot again turned into equinovarus position. Sometimes now he sits with both bare feet perfectly straight, but he still has to be tied in his chair because he never has walked or stood or even sat erect without restraint.

Meyer walked without crutch, cane or other support in a sloppy "whirling dervish" type of athetotic gait at 8 years of age. When he was 12, a contracture release operation was carried out on his left leg to get his heel down. Now he acts like a lazy dog who leans against the wall to bark, and frequently he falls as his left heel again con*stantly retreats from the floor in a superior*

* All of Birmingham, Ala.

direction. It is hoped that in a year or two of intensive training, Meyer will be able to walk as well as he did before the operation was performed.

Mary is an intelligent 14-year-old spastic child afflicted with progressive dystonia musculorum deformans. She can lie in bed only on her left side with knees and hips in such acute flexion and adduction that proper perineal care is impossible. During the past year, traction, spica casts, hamstring sectionings and Soutter osteotomies were employed in an attempt to straighten her legs. Violent involuntary extremity twitchings continued unabated, and now she is as badly deformed as ever. In desperation, a chemopallidectomy is being considered. If this procedure proves to be successful, it will be the answer to the problem of this child as well as other such children.

In view of the foregoing, we are beginning to worry about imposing a surgical procedure on any individual afflicted with cerebral palsy; we question whether or not mutation for better function can be expected, or whether or not a shift to a different more serious disability will occur.

Are there any good operations for spastics? In some, wrist fusions are good.[9] A 16-year-old boy confined to a wheel chair with quadriplegic athetotic movements and habitual flexion at hips and knees was made very happy when wrist arthrodeses allowed such improved finger function that he could hold a book and turn the pages. We did not straighten his legs, because it seemed that it would be wasting the time of this above-average intelligent individual to encourage him to devote hours of every day for months and maybe years in an attempt to learn the art of walking in the sloppy manner that it would be even if he were to succeed. We felt that his time would be better occupied by going to school in his wheel chair to develop his mind since our surgery had removed the handicap of useless hands. Recently a girl became the motivating factor in this boy's life. The result is that he has begun to learn to walk grasping parallel bars for support.

Orthopaedic surgeons can blame themselves, at least in part, for the tendency during the past few years to depreciate the value of their services in the management of cerebral palsy.[2] Some continue to be "rugged isolationists" in so far as co-operation with management teams is concerned. Individualists of this type often grasp the spastic foot at first sight and lengthen the tendo achillis, not taking time to consider the individual's "will to do" or developmental pattern. They seem to forget—if they ever knew—that operations do not teach the victims of cerebral palsy how to do anything when they did not know how before the surgery was performed.[1]

Usually, spastics should not be regarded as patients but as students with handicaps that impede educational progress. Influencing emotional factors are present, and each individual requires and deserves careful analysis in this regard.[11]

Very often the spastic's environment has to be scaled down before progress in learning is accomplished. To face the matter realistically, he has to compete with his physically unimpaired peers; therefore, we should warn him against setting his sights too high and help him to set an attainable objective.[10] This may stimulate his ambition without raising false hopes.[7]

We advocate the management of those with cerebral palsy by a team that includes a pediatrician, a psychiatrist, a physiatrist, a speech therapist, specially trained schoolteachers, a social worker, the child's parents, when possible, and the orthopaedist.[4] Many of the other medical and surgical specialists become necessary in individual instances.[13]

The orthopaedist's role should include the prevention of deformities and the development of useful function of the upper extremities and independent ambulation.[3]

To keep education in useful function as the rightful primary aim, operations must

be considered for their effects on dynamics rather than on producing only a static improvement in appearance.[12]

Orthopaedic surgery seldom deserves the center of the stage, and in the majority of instances operations should be preceded by *muscle training and other aspects of treatment* to observe, stimulate and sustain the individual's "will to do." If proper motivation is not present and does not develop during this period, surgical results usually will be failures in so far as appreciable improvement in prehensile function is concerned.[17]

Most operations should not be undertaken until an insurmountable barrier arises to further progress in muscle training in a well-motivated spastic who understands and desires the surgery.

The orthopaedist should hesitate to advise an operation until the other team members concur that the impediment persists and that surgery is the only remaining method with a chance of eliminating the obstacle to physical and mental progress.

In contrast with its frequent occurrence in poliomyelitis, scoliosis rarely is seen in those with cerebral palsy. We do see nonfixed scoliosis occasionally in athetoids, and, although the legs prove to be equal in length, often a lift on one shoe will result in a shift to a straight back.

Usually it is better to treat foot equinus by daily tendo achillis stretchings and encouragement of active dorsiflexion, with brace wearing, than by ordinary tendon lengthening operations.

Tenotomy continues to be popular; 13.2 per cent of the children in one cerebral palsy center have had this operation performed on one or both feet, and they are still "toe walking."

Surgical scars often have resulted in the worsening of subsequent treatment problems because of the additional psychic trauma that they have produced. We agree that tendo achillis lengthenings usually have no permanent value and that postoperative recurrence of "tiptoe" is appallingly frequent.

Attention to muscle evaluation will show the futility of this procedure in most instances. If central control of muscles is absent, opposing muscles cannot be expected *to maintain a foot in neutral position* after such an operation for architectural improvement. In fact, frequently toe-flexor activity follows tendo achillis lengthening in an athetoid, and this may cause more disabling deformity than the original equinus. We consider it to be more logical to attempt to *train the dorsiflexors to function, and, if* their opponent power increases to a standstill point only short of being satisfactorily adequate, then tendo achillis lengthening may be worth while.[21]

Many children with cerebral palsy who have flat long arches with valgus heels and severe ankle pronation are fitted with heavy shoes, longitudinal arch supports and medial border heel wedges. Operative consideration is deferred until the mid or the late teens unless persistent foot pain on weight-bearing develops. Triple arthrodesis and occasionally additional ankle fusion then may be in order.

Athetoids appear to be happier than spastics. Also, they may be more intelligent. But surgical results are poorer for them, as their *involuntary movements tend to shift from* the restrained to the unrestrained muscle groups.[20] A surgically corrected foot may be followed by disorganization of the hip rotators, therefore, we brace athetoid deformities from 6 months to a year before considering stabilization operations to provide a period in which we can study deformity shifts. If poorer over-all function results, the surgical idea is discarded.

We feel also that surgical procedures in athetoids are more questionable because adequate individual muscle evaluation in them frequently is impossible. The "pure spastics" remain better candidates for surgery, and athetoids should continue to be treated by

choice with prolonged bracing and physical therapy.[15]

When muscles are strong enough to overpull the resistance of a spring or an elastic, they gain in strength by the resisted action. Cerebral palsy affection of a brain results in too much muscular strength in contrast with the muscular weakness of poliomyelitis; therefore, braces for these paralytics must be rigid and heavy enough to control abnormally strong muscles, and we agree with Bunnell that there can be "no elastics for spastics."

The tendency to recurrence of the contracted heel cord can be due to the habitual position of the foot at night in bed. Walking may keep it under control during the day, but recurrence comes at night. It is true that spastic and rigid tendons do not keep pace in growth with growth in length of bones to which they are attached, so that the corrective force provided by braces must be continued throughout the growth period, including the wearing of the braces during the night.

We use heavy braces in most athetoids who do not have deforming contractures but walk in a bizarre and an ungainly way, in an endeavor to achieve a more graceful and inconspicuous gait. The braces are applied at the beginning of the walking period to prevent the establishment of poor habits, since the longer the child is allowed to walk badly the harder it will be to break up the pattern.[14]

We feel that adductor and flexor tenotomies sometimes are permissible to facilitate walking training, and in some instances we carry out hamstring tendon lengthenings or transplantation of hamstring attachments from below the knee to the backs of the femoral condyles to overcome disabling strongly resistant knee flexion.[6] These procedures are deferred until after many months of passive and active stretching exercises daily and splinting nightly have proved to be inadequate.

We have had no experience with quadriceps mechanism advancement operations as advocated by Chandler and others to correct persistent knee flexion.

Individuals with cerebral palsy deserve early and periodic muscle-status examinations as employed in good management of poliomyelitis paralysis. No surgery should be done on a spastic muscle until the status of its antagonist has been determined.[8] Scissors gait can be caused by flaccidity of the gluteus mediae and the tensor fascia lata, and in these 30 to 40 per cent of patients obturator neurectomy and adductor tenotomy result in tragedy. The surgically induced paralysis of the adductors increases disability, and the patient no longer is able to approximate the knees for balance in attempts at standing and walking. The ability to help a muscularly unbalanced individual by this operation remains questionable. We agree with Eggers that obturator neurectomy probably should be reserved as a nursing care adjunct for bedridden scissors-legged people.

Walking with the feet in internal rotation may be due to femoral torsion. Forced positions of the lower extremities, resulting from sitting persistently with the legs folded posteriorly under the body and sleeping habitually in the abdominal prone position, cause femoral torsion more often than does muscle imbalance from a central lesion. We feel that subtrochanteric femoral osteotomies sometimes are justifiable and helpful.

Generally, the results of our operations on the upper extremities in those with cerebral palsy have been poor, for after all such surgery can only improve architectural appearance.[19] We agree that upper-extremity operations do not restore skillful functions and that physical and occupational therapy must be depended on to obtain improvement in fine manual dexterity.[16]

In some instances, radially deviated hands have been improved functionally by resection of the distal end of the ulna. Our pronator

teres muscle release operations have failed permanently to increase forearm rotation ranges.

If extension of a flexed thumb and fingers becomes possible after prolonged persistent exercises, then wrist arthrodesis at the age of 12 or 13 years will help to ensure permanence and further improve digit function.

We are unable to formulate rules indicating or contraindicating surgical interference in cerebral palsy. Deformity is only one aspect of the handicap; the emotional and the mental make-up of each individual always influences the degree of success or failure of an architectural improvement procedure.

We cannot appraise an operation by its aid in overcoming a local deformity alone, for it should contribute also to the individual's over-all habilitation.[18]

Desire never has been and never will be fulfilled by surgery. Functional independence results from the development of coordinated voluntary biophysical efforts, and if the individual does not have a "will to do" the door to successful achievement cannot be unlocked.[5]

If the orthopaedic surgeon wishes to give his best to the handling of the problem of cerebral palsy, he must be broadminded, tolerant and content to serve as a vital, and not a superimportant, part of the management team.

When a cerebral palsy student reaches maximum improvement in physical function, no time should be wasted in continuing physical therapy or orthopaedic treatment. By doing so the purpose of helping the patient to become socially competent and acceptable may be forgotten. The goal should always be to help these handicapped individuals to take their place in society both to their own satisfaction and that of those with whom they come in contact.

SUMMARY

The authors discuss some [illegible] surgical procedures advocated [illegible] of deformities accompanying cerebral palsy and point out that these operations are not an important over-all part of the habilitation of those afflicted with cerebral palsy. Teams of medical specialists are considered to be necessary for the improved management of these patients.

REFERENCES

1. Baker, L. D.: A rational approach to the surgical needs of the cerebral palsy patient, J. Bone & Joint Surg. 38A:313-323, 1956.
2. Barnett, H. E.: Orthopaedic surgery in cerebral palsy, J.A.M.A. 150:1396-1398, 1952.
3. Bost, F. C., Ashley, R. K., and Kelley, W. J.: Role of the orthopaedic surgeon in treatment of cerebral palsy, J.A.M.A. 160:256-258, 1956.
4. Brandt, S.: The treatment of patients with cerebral palsy at the Society and Home for Cripples in Denmark, *Månedsskrift for praktisk Loegegerning og Social Medicin* (Danish medical magazine), Copenhagen, 1956.
5. Denhoff, Eric, Holden, R. H., and Silver, M. L.: Prognostic studies in children with cerebral palsy, J.A.M.A. 161:781-784, 1956.
6. Eggers, G. W. N.: Transplantation of hamstring tendons to femoral condyles in order to improve hip extension and to decrease knee flexion, J. Bone & Joint Surg 34A:827-830, 1952.
7. ———: The present status of surgery in cerebral palsy, course given at meeting of the American Academy of Orthopedic Surgeons held in Chicago January 24, 1954.
8. Fuldner, R. V.: Physical examination of the cerebral palsied child, J.A.M.A. 148:34-41, 1952.
9. Goldner, J. L.: Reconstructive surgery of the hand in cerebral palsy and spastic paralysis resulting from injury to the spinal cord, J. Bone & Joint Surg. 37A:1141-1153, 1955.
10. Hipps, H. E.: Basic teaching training principles for the patient with cerebral palsy, Am. J. Surg 91:715-718, 1956.
11. Krusen, F. H.: The team approach to rehabilitation of the disabled, Proc. Staff Meet. [illegible] 30:400-406, 1955.
12. McC[illegible] R.: Surgical treatment of spa[illegible] in Am. Acad Orthop. Sur[illegible] Course Lectures, vol. 6, [illegible] Arbor, Edwards, 1949.

13. Perlstein, M. A., and Barnett, H. E.: Nature and recognition of cerebral palsy in infancy, J.A.M.A. 148:1389-1397, 1952.
14. Phelps, W. M.: Braces, lower extremity, cerebral palsies, *in* Am. Acad. Orthop. Surgeons Instructional Course Lectures, vol. 10, pp. 303-306, Ann Arbor, Edwards, 1953.
15. ———: Long-term results of orthopaedic surgery in cerebral palsy, J. Bone & Joint Surg. 39A:53-59, 1957.
16. Schwartz, F. F.: Physical therapy for children with cerebral palsy, J. Internat. Coll. Surgeons 21:84-87, 1954.
17. Schwartz, R. Plato, *et al.*: Motivation of children with multiple functional disabilities, J.A.M.A. 145:951-955, 1951.
18. Shurbet, R. L.: Living Abundantly. Charlanne Chatter (monthly mimeographed publication of the Charlanne School for Cerebral Palsy, Birmingham, Ala.), January, 1946.
19. Steindler, Arthur: The reconstruction of upper extremity in spinal and cerebral paralysis, *in* Am. Acad. Orthop. Surgeons Instructional Course Lectures, vol. 6, pp. 120-133, Ann Arbor, Edwards, 1949.
20. Tachdjian, M. O., and Minear, W. L.: Hip dislocation in cerebral palsy, J. Bone & Joint Surg. 38A:1358-1364, 1956.
21. Terhune, S. R.: New apparatus for walking training in cases of weakness of the lower extremities and the back in children, South. M. J. 27:881, 1934.

Le Rolo del Chirurgo Orthopedic in le Tractamento de Patientes de Paralyse Cerebral

Summario in Interlingua

Le autores presenta lor errores chirurgic ab un periodo de 25 annos de tractamento de paralyse cerebral como problema orthopedic. Iste errores induceva les a facer se advocatos del studio cooperative de omne caso individual, i.e. de consultationes con pediatros o internistas, psychiatros, physiatros, laliatros, e le parentes ante le initiation de un intervention chirurgic. Illes opina que operationes deberea esser utilisate solmente si nihil altere pote eliminar le obstaculos al progresso physic e mental del victima de paralysis cerebral.

In le majoritate del casos, le prolongation del tendine de Achilles es a condemnar. Exercitios diurne de traction e le portar de un apparato es a preferer

Arthrodeses chirurgic es considerate como utile in cautemente studiate casos individual in que illos pote resultar in un melioration del function general per corriger deformitates fundamental, sed transplantas de tendine es considerate como generalmente non resultante in successos. Il es un exception de iste regula general que le autores pote reportar lor satisfaction con le resultatos de lor transplantationes (typo Eggers) de tendines del poplite ab infra le genu a super le dorsos del condylos femoral pro corriger persistente flexion del genu e ambulatura "forficoide."

Neurectomia que visa al paralysation de gruppos de musculos deformante merita nulle sympathia.

Osteotomia effectuate pro corriger deformitates rotational del ossos longe se ha provate utile in multe casos.

Le resultatos de operationes del extremitates superior—con le exception de arthrodeses carpal—es considerate como generalmente pauco favorabile.

Le autores opina que le concepto del "attacco cooperative" contra le problema de paralyse cerebral merita omne supporto e que le chirurgo orthopedic non debe considerar se como le autoritate per excellentia con respecto a iste tremende problema de rehabilitation que usque nunc se ha provate inresolvibile per le ressources del chirurgia orthopedic sol.

17

Morquio's Disease

MEINHARD ROBINOW, M.D.*

HISTORY

In 1929, Morquio, of Montevideo, Uruguay, reported a family in which 4 out of 5 children were afflicted with an unusual skeletal disorder which he called "a form of familial osseous dystrophy."[33] In his first report, Morquio described the morphologic and the radiographic features of two of the children, as well as the results of some laboratory studies. The other two children were examined several years later and formed the subject of a supplementary report.[34] Both publications are well documented with photographs and roentgenograms. They are models of medical writing. The descriptions are vivid; the style is lucid and concise. So thorough was the examination that little of importance has been added since. Morquio clearly recognized and stated that his cases were not variants of some more common disorder but that they represented a new and distinct familial disease. Morquio also deserves credit for stressing the role of parental consanguinity at a time when few clinicians were familiar with the basic facts of human genetics. Meanwhile Brailsford, in England, who had studied an isolated case of the same type, independently recognized it as a new disease and published it a few months after Morquio under the name of chondro-osteodystrophy.[3] A search of the literature by Brailsford and later by others revealed that similar cases had aroused medical interest earlier. Some cases which now would be called Morquio's disease had been described under various other labels as varieties of dwarfism, atypical achondroplasia, etc.[12,19,46] Some additional cases reported in the older literature may have been Morquio's disease, but many of these reports were not well enough illustrated to permit of reliable retrospective classification.

A closely related familial disease, commonly called gargoylism, was first described by Hunter in 1917[22] and Hurler in 1919,[23] but it seems to have been forgotten soon afterward. It was not rediscovered until some time after the first reports of Morquio and Brailsford had appeared.

Recent reviews covering most of the pertinent literature are those of Whiteside and Cholmeley (Morquio's disease),[47] Jervis (gargoylism),[27] Cocchi[8] and McKusick (both diseases and various associated disorders).[28]

CLASSIFICATION AND NOMENCLATURE

There is much overlapping between these two diseases or syndromes, and their mutual relationship has remained a matter of con-

* The Yellow Springs Clinic, Yellow Springs, Ohio.

The author is indebted to Dr. S. M Garn, of the S. Fels Institute for Child Development, Yellow Springs, Ohio, for the constructive criticism and the many helpful suggestions offered by him.

troversy. A procedure commonly followed in classification is to select a group of cases which closely resemble those described by Morquio and Brailsford and call these "typical" Morquio's disease. Similarly, one can define "typical" gargoylism. All remaining cases then are termed *atypical, intermediate* or *incomplete* forms. Such a course will be followed in the subsequent description of Morquio's disease, though it will be shown later that this type of classification is of doubtful merit and is sanctioned mainly by historical reasons.

There is a multiplicity of terms that reflects the conflicting nosologic concepts and classifications. In the American literature the disorder is best known as Morquio's disease, and that term will be used throughout this article. Synonyms common in the Anglo-American literature are chondro-osteodystrophy[3] and osteochondrodystrophia deformans,[43] to which Brailsford's and/or Morquio's names usually are added for better identification. A milder form of Morquio's disease, to be discussed further below, is sometimes referred to as Silverskiöld's disease. Many German writers use the comprehensive term *hereditary polytopic enchondral dysostosis,* which includes Morquio's disease, gargoylism and various "atypical" groups. Several other names have been offered, but since none of them has found wide acceptance they need not be enumerated here.

The term *gargoylism* now is used more commonly than its synonyms Hunter-Hurler's or Pfaundler-Hurler's syndrome, dysostosis multiplex and lipochondrodystrophy.

DEFINITION

Morquio's disease may be defined as a characteristic growth disorder of cartilage and cartilage-derived bone, presumably due to a hereditary *metabolic disorder. Involvement* of other tissues and organs is minimal or absent.

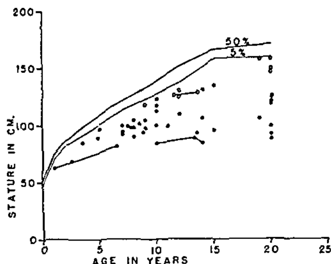


FIG. 1. Short stature of patients with Morquio's disease. Measurements gathered from the literature. Open circles represent patients with the milder form, the so-called *Silverskiöld's disease.* Lines connect consecutive measurements on the same patient. The norms used here are combined figures for both sexes. Note that all Morquio cases fall below the lower 5 per cent of the normal range.

ONSET

While, undoubtedly, the underlying metabolic disorder is congenital, nearly all children have been described as normal at birth. A notable exception is the family described by Whiteside and Cholmeley,[47] in which at least two children showed spinal deformities at birth. Congenital clubfeet were recorded in several other cases. Generally, this is not considered to be a symptom of Morquio's disease, but the incidence is too high to be fortuitous. It would be interesting to know whether or not a careful physical and roentgenographic examination soon after birth would reveal early signs of Morquio's disease more often. Several of the children who developed Morquio's disease were born in hospitals and received the routine newborn examinations, but apparently none of them were roentgenographed soon after birth or were examined with the special purpose of determining the presence of a skeletal disorder. In gargoylism, on the other hand, ex-

tensive skeletal changes have recently been demonstrated soon after birth.[6]

GROWTH AND EARLY DEVELOPMENT

Growth and motor functions may be obviously retarded from birth, but more often early development appears to be quite normal. The first signs of the disorder rarely are noticed before the end of the first year, but they may not make their appearance until the fifth year.[30] As the skeletal deformities develop, growth slows down and often virtually comes to a halt in early childhood. Growth failure and progressive spinal deformities combined may actually bring about a shortening of stature. Thus, the growth pattern in Morquio's disease is quite different from that in achondroplasia. In the latter disorder the abnormal proportions already are obvious at birth, and growth follows this faulty pattern from fetal life to maturity. The growth abnormality is continuous but not progressive, as in Morquio's disease or gargolyism.

GENERAL APPEARANCE

In the milder forms and in the early stages of the typical cases, the general appearance does not differ greatly from that in some other disorders or even from the norm; but *in the well-developed cases the deformities* are so striking that Morquio's disease (or one of its variants) can be diagnosed at sight in the same way as achondroplasia or mongolism.

Stature is always reduced, even in the milder cases (Fig. 1). In the more severe cases, the patients are dwarfed to an extent rarely equaled in other diseases. The reduced height is caused mainly by the short-

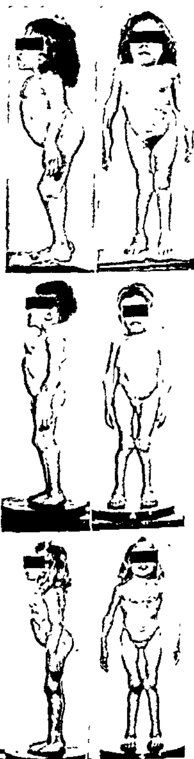


FIG. 2. Three siblings with a variant of Morquio's disease. The ages, from above downward, are 13 years and 6 months, 11 years and 6 months, and 8 years and 10 months. There is a striking resemblance between Morquio's original patients[33] and these children This sibship illustrates some of the problems in classification The children were under observation for many years and were considered to be typical examples of Morquio's disease until the gradual development of corneal clouding threw doubt on the correctness of the original diagnosis. All 3 children, now young adults, have normal intelligence and neither hepatosplenomegaly nor cardiac disease. (Personal communication from Dr M P. Moldauer, Massachusetts General Hospital, Boston) These children were described previously by Garn & Hurme[16] and Cohen & Garn.[9] (Forsyth Dental Infirmary for Children, Boston)

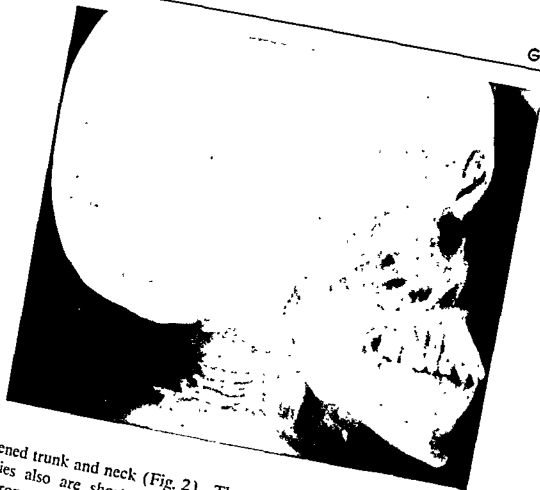


FIG. 3. Lateral roentgenogram of head and neck, Morquio's disease. Same patient as boy in Figure 2. Note the essentially normal cranium and the severely distorted cervical vertebrae of this boy. (Cohen & Garn: Am. J. Orthodontics 40:671)

ened trunk and neck (Fig. 2). The extremities also are shortened in most cases but proportionately less severely. The resultant proportions are the opposite of those in achondroplasia. In other respects the two disorders have much in common, and achondroplastic features are quite pronounced in some families with Morquio's disease.

The head is the least deformed part of the body. Usually, it is described as normal; rarely, as somewhat enlarged. Premature synostosis of the sutures, resulting in scaphocephaly, has been unduly frequent.[47] The latter is of interest, since it indicates faulty growth of membranous bone. Growth of the cartilage-derived bones of the face and the base of the skull is only mildly disturbed or not at all (Fig. 3). The bridge of the nose often is somewhat depressed, though rarely as much as in achondroplasia. The eyes sometimes are more widely spaced than normal. Facial expression usually is described as intelligent and appealing, thus contrasting with the dull, coarse, even repulsive features which have given gargoylism its name.

The neck becomes greatly shortened in the course of the illness (Figs. 2 & 3). The cervical curve is exaggerated. Neck movements may be severely restricted. The head, especially the occiput, seems to rest directly on the shoulders.

The thorax usually shows a marked kyphosis, often a kyphoscoliosis. The changes in the thoracic and the lumbar spines generally are the first abnormalities noted by the parents. The chest shows a peculiar type of pectus carinatum (Fig. 2). The sternum extends almost horizontally from its clavicular junction, then angles sharply downward in its mid-section. The ribs are nearly horizontal. Vital capacity may be dangerously reduced.

The lumbar spine often is deformed by a gibbuslike kyphosis centered about the first lumbar vertebra. In some cases, especially those with dislocation of the hips, the lumbar kyphosis is replaced by an exaggerated lordosis. A prominent pot belly, considered to be characteristic, is presumably due to the shortened vertebral column.

The extremities show various degrees of shortening. In some cases the relative pro-

portions of proximal and distal parts are essentially normal; in others, they are strongly suggestive of achondroplasia. The hands may nearly reach the knees, or, less commonly, they may barely extend below the level of the hip joints. The joints may show striking excess mobility[18,33,34] or marked restriction of movements.[30] Sometimes excess mobility is found in some parts and rigidity in others. In Morquio's cases and some others, the dorsum of the hands could be folded back against the forearms. On the other hand, shoulder abduction usually is limited, and often elbows, hips and knees cannot be fully extended. The joints look unduly prominent, as in rickets, and most of the early cases were first so diagnosed and treated. The usually scant subcutaneous tissue and the atrophic musculature tend to exaggerate the bony defects. The wrists are deviated to the ulnar side. The hands usually are large in proportion to the arms. The hands may be normal in shape, or they may be short, trident shaped and somewhat rigid, as in achondroplasia.

The hip joints always are involved, usually severely. There is limitation of abduction, rotation and extension. Subluxation or dislocation commonly develops during the course of the illness. The habitual posture is quite characteristic: the patient stands with hips and knees in semiflexion (Fig. 2). Some children habitually support the trunks by placing their palms on the thighs.[4,47]

Knock knees usually are present, often to an extent found in no other condition. The combination of excessive hip-joint adduction with severe knock knees can produce a very bizarre stance in which the knees are crossed while the feet are far apart. Most patients have severe flatfeet, though in a few "atypical" cases congenital clubfeet have been reported.[20,25]

ROENTGENOLOGIC FINDINGS

X-ray examination shows a severe generalized disturbance of cartilage-derived bone. The outstanding changes are seen in the growth zones. They consist of delay in ossification, marked irregularities of the line of ossification, bizarre deformities of the epiphyses and, commonly, osteoporosis. The transformation of cartilage into bone is faulty. The new-formed material is mechanically inadequate and is deformed by the stresses of muscular pull and weight-bearing Growth disturbances and structural inadequacies from other causes—as, for instance, juvenile osteochondritis or hypothyroidism —may produce a similar roentgenologic appearance. Therefore, x-ray examination of a single joint never is diagnostic, and even a skeletal survey may leave some doubts.

The appearance of ossification centers almost always is delayed. This applies to the epiphyses of the tubular bones as well as to the carpals and the tarsals. When finally the centers appear, usually they are abnormally shaped, sometimes multicentric or fragmented. Some of the carpal centers may not form at all. Occasionally, fusion of certain epiphyses with the shaft is delayed.

The metaphyses of the long bones, especially of wrists, knees and ankles, are expanded and flaring, showing some resemblance to rickets and to certain forms of achondroplasia. While diaphyseal bone generally is normal, a few children have had an undue number of fractures.[10]

The skull presents only minor changes (Fig. 3). The sella may be unusually small.[5] Large posterior clinoid processes are mentioned by several authors.[5,47] Premature synostosis already has been mentioned (p. 141). The deciduous and the permanent teeth in at least one family[16] have shown an unusual type of enamel defect Here is an ectodermal component of a disorder otherwise limited to cartilage and bone.

The vertebrae show striking abnormalities (Fig. 4). The vertebral bodies always are flattened, while the intervertebral disk spaces usually are of normal size and, therefore, seem large by comparison. The flattening of the vertebrae is such a striking feature that several of the early cases were published

as "generalized platyspondylia." The contours of the vertebrae may be quite bizarre, especially in lateral views of the lumbar region. The anterior borders of the vertebral bodies are irregular and may show peculiar beak-shaped protrusions. L-1 and L-2 often are dislocated posteriorly and form the apex of the above-mentioned gibbuslike kyphosis.

The Pelvis. As a rule, in achondroplasia the female pelvis is so deformed that spontaneous delivery is impossible. Changes affecting the pelvic diameters have not been reported in Morquio's disease. In several of the milder cases, pregnancy and normal delivery took place.[5,21] Only one pregnancy in a severely affected woman has been reported.[12] In this case the pregnancy was terminated prematurely by caesarean section.

The Extremities. The extent to which these are involved varies considerably from family to family (Figs. 5 & 6), and in each case it varies with age. Epiphyseal changes generally are rather mild in the shoulders and the elbows, while abnormalities in wrists and hands usually are quite striking. The distal ulna is shortened considerably; consequently, the wrist is held in ulnar deviation. The distal ends of radius and ulna are broad and irregular. The metacarpals and the phalanges may be normally slender or distinctly shortened and chubby (Fig. 6).

The changes in the lower extremities often are more pronounced, possibly because of



FIG. 4. Lateral roentgenogram of dorsolumbar spine, Morquio's disease. Note the severe deformities of the bodies of D-8 to L-1 and the posterior displacement of L-1. (Patient of Dr. A. DePalma, Philadelphia. For other roentgenograms and photographs of this patient see Figs. 5, 7 & 8.)

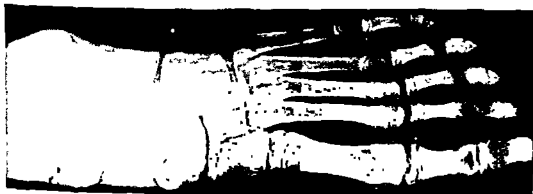


FIG. 5 Roentgenogram of foot, Morquio's disease. Same patient as in Figures 4, 7 and 8. Note that only the tarsal navicular seems to be affected. The roentgenographic appearance suggests osteochondritis. (Patient of Dr. A. DePalma, Philadelphia)



FIG. 6 Roentgenograms of the hands in 3 siblings with Morquio's disease. Same patients as in Figure 2. The oldest child on the left, the youngest on the right. Note the marked intrafamilial differences. (Forsyth Dental Infirmary for Children, Boston)

the effect of weight-bearing. The hip joints are the structures affected most constantly and most severely (Fig. 7). The acetabula are enlarged (coxa magna) and irregular in outline. The capital epiphyses and sometimes the entire femoral heads become progressively deformed and fragmented, and eventually they may disappear completely. There may be either coxa valga or coxa vara. Coxa valga is said to be more common in Morquio's disease; coxa vara, in gargoylism. Next in severity are the changes in the lower epiphysis of the femur. Involvement of the feet is comparable with that of the hands. Sexual maturation occurs at the usual time, and in most cases epiphyseal lines close as expected However, in a few cases delayed fusion of certain epiphyses persisted well into adult life.

INVOLVEMENT OF OTHER ORGANS AND TISSUES

The Musculature. In rare instances the musculature is well developed and remains so. More often the muscles become progressively weaker as the deformities develop, and growth becomes arrested. Eventually, because of extreme weakness, many patients become bedridden. In the case of Einhorn *et al.*,[14] muscular atrophy and subsequent death were due to spinal cord compression secondary to bony changes in the atlanto-occipital region, but in most cases the muscular weakness apparently was not associated with neurologic changes and was more severe than could be explained by the bone and the joint defects.

Intelligence sometimes is obviously impaired, but more often it is normal or as nearly normal as might be expected in children who are forced to live under highly restricted conditions. Reports on intelligence have more often been based on impressions rather than on intelligence tests.[17]

In gargoylism one finds, in addition to the skeletal changes (which may be indistinguishable from those in Morquio's disease), certain visceral changes associated with intracellular deposition of an abnormal metabolite in various tissues. These changes include enlargement of liver and spleen, cardiac enlargement and failure, corneal clouding, deafness, umbilical and inguinal hernias,



FIG. 7. Pelvis and hip joints, Morquio's disease. Same patient as in Figures 4, 5 and 8. The involvement is far more extensive than in Perthes' disease. (Patient of Dr. A. DePalma, Philadelphia)

mental deficiency and deterioration and characteristic changes in the leukocytes. Such changes are absent from Morquio's disease by definition. Those diagnosed originally as Morquio's disease generally are reclassified as soon as such visceral changes are noticed.[45]

LABORATORY FINDINGS

No consistently abnormal laboratory findings have been reported.[47] Routine blood-chemistry values, including those for calcium and phosphorus, have been normal. Occasionally elevated serum phosphatase has been found. No disturbance of renal or hepatic function or of endocrine balance has been demonstrated. The basal metabolic rate sometimes has been unexpectedly high. This is possibly due to the fact that no suitable standards exist for patients so deformed.

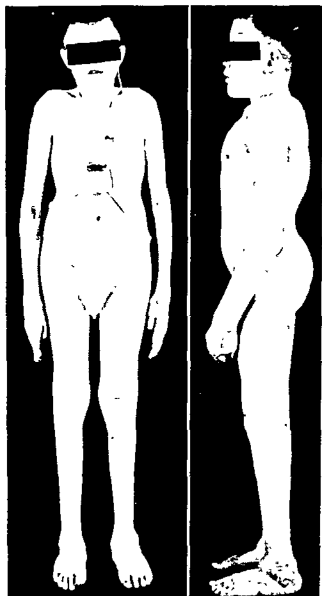


FIG 8. The patient whose roentgenograms are shown in Figures 4, 5 and 7. The reason for this patient's wearing a hearing aid is not known to the author. Deafness is common in gargoylism but not in Morquio's disease (Patient of Dr A. DePalma, Philadelphia)

PATHOLOGY

Pathologic information is disappointingly scarce. Only one autopsy[14] and very few bone biopsies[1,43] have been reported in the literature. A specimen of diaphyseal bone revealed nothing of importance.[1] A biopsy of the epiphyseal growth zone[43] showed a severely disorganized pattern. The zone of proliferating cartilage was narrowed, the columnar arrangement of the cartilage cells was irregular, and some of the cartilage cells appeared to be distinctly abnormal. Calcification and ossification also proceeded in a disorganized manner. Islands of cartilage cells were found enclosed among calcified matrix and bone trabeculae. Shelling[43] did not consider the histologic picture to be specific, but from his description it is not clear whether or not the histologic changes differ from those found in gargoylism. Many autopsies have been performed on cases of gargoylism. Characteristic degenerative changes with intracellular storage of a complex carbohydrate (not a lipoid, as thought formerly) are found quite consistently in various internal organs, especially liver, spleen, heart and brain. Since no such changes were mentioned in the autopsy report of the case of Einhorn *et al*,[14] one may confidently assume that they were absent.

PROGNOSIS

In many of the milder cases the disability remains slight, but in the more severely affected patients it is often progressive. Sometimes extreme muscular weakness and wasting develop, and death supervenes in the second decade. The impaired vital capacity greatly increases the risk of respiratory infections Nevertheless, most patients with Morquio's disease seem to survive childhood Life expectancy is substantially better than in typical gargoylism

TREATMENT

The disease process is not affected by any therapy tried so far. Vitamin, mineral and endocrine treatment is ineffective. Orthopaedic therapy is limited to the prevention and the correction of the secondary mechanical deformities. The results of surgical correction during the active stages often have been disappointing.

ETIOLOGY

Morquio's disease shows a distinct familial tendency, and there are good reasons to believe that all cases are due to a genetic fault (see below). During the past two decades, more and more hereditary diseases have been traced to a single defect in the chain of intermediary metabolism, presumably the complete absence or the partial deficiency of a single enzyme. The course of Morquio's disease suggests that this metabolic disorder involves directly or indirectly the elaboration of some toxic substance which has a cumulative effect on cartilage growth and differentiation, and possibly the metabolism of some other tissues. This hypothesis would make Morquio's disease comparable with some other hereditary disorders which are active only during certain growth periods, as, for instance, hereditary vitamin-resistant rickets or hypophosphatasia.

While no metabolic abnormality has been demonstrated so far, it should be remembered that the biochemistry of bone growth and development still is very poorly understood

CLASSIFICATION AND DIFFERENTIAL DIAGNOSIS

The original cases of Morquio and Brailsford had a great deal in common and, therefore, suggested a well-defined disease entity. These cases and those which closely resembled them form what is generally called "typical" Morquio's disease. This rather arbitrary morphologic definition has proved to be unsatisfactory, because there are at least as many "atypical" and "intermediate" cases. The heterogeneous assortment of "atypical" cases present a challenge to attempts at dif-

ferentiation, classification and nomenclature. These problems have been attacked by many authors but never have been solved to general satisfaction.

INTERFAMILY AND INTRAFAMILY VARIABILITY

The total variability of the disease picture may be divided into interfamily and intrafamily variations. In Morquio's disease and related skeletal disorders, the interfamily variations often are marked. Some of the families show severe vertebral flattening with only relatively mild involvement of the extremities; in other families the extremities, especially the hip joints, are severely involved while the spine shows only minor changes. In some families the affected members are inconvenienced only mildly, while in other families the disorder becomes completely disabling in childhood or adolescence.

On the other hand, the intrafamily differences rarely are so striking. The four siblings in Morquio's family were amazingly alike, and so were the affected siblings in most other families. In a few sibships, differences have been more noticeable. An example of intrafamily differences in hand configuration is shown in Figure 6.

DIFFERENTIATION FROM GARGOYLISM

This is the most troublesome problem in differential diagnosis. As in Morquio's disease, there are descriptions of "typical" gargoylism. But in gargoylism there is much more justification for a "typical" picture since the typical case is also the common form. It represents the severe form of the disease in which the disease process itself (not the complications) often causes death in the first or the second decade and autopsy shows characteristic histopathologic changes. But here, too, not all cases are typical or complete. Enlargement of liver and spleen may be absent, and the intelligence may remain unimpaired. Corneal clouding may be absent or delayed until the second or the third decade. Sometimes it cannot be discovered without slit-lamp examination. The granulations of the leukocytes are common,[40,41] but they are likely to be overlooked unless they are searched for[49] and, therefore, were not discovered until 1941.[40] On the basis of the skeletal changes the differential diagnosis from Morquio's disease offers similar difficulties.[8,13,49] Certain roentgenologic signs have been described as typical for gargoylism,[6,7] but these are not obligatory. Nor can the autopsy findings be regarded as decisive in the differential diagnosis, since the single autopsied case of Morquio's disease forms no adequate basis for comparison, especially since it was clinically unique because of the fatal neurologic complications.[14]

Whether a case is diagnosed as Morquio's disease or gargoylism may depend on the child's age. This probably accounts for the report of Böcker,[2] who described three families in which both Morquio's disease and gargoylism appeared in the same sibship.

It is tempting to go one step farther and ask if Morquio's disease should be regarded as a variety of gargoylism[41] or if both syndromes are different manifestations of the same disorder.[13] These questions will be discussed further after an analysis of the genetic aspects.

DIFFERENTIATION FROM ACHONDROPLASIA AND OTHER SKELETAL DISEASES

The only other disease which occasionally can prove to be a real problem in differential diagnosis is achondroplasia. Typical achondroplasia is distinguished easily enough, but that disorder probably is heterogeneous too, and cases exist which in many ways seem transitional to Morquio's disease.[20] Rickets and related disorders (renal rickets, hypophosphatasia, cystinosis, etc.) are now defined well enough clinically, radiologically and biochemically so that they should no longer be confused with Morquio's disease in spite of superficial resemblances.

GENETIC ASPECTS

The genetics of Morquio's disease have been studied extensively. According to their mode of inheritance, the reported cases may be divided into three groups:

Group 1: Dominant Inheritance. In some families Morquio's disease is found in two or three generations and is passed on by affected members to some of their offspring. Cocchi,[8] in his review of "polytopic enchondral dysostoses," found dominant inheritance in 13 families with a total of 43 affected members. Helweg-Larsen and Mørch,[20] as well as Cocchi, have pointed out that the dominant form of Morquio's disease is milder. Stature is shortened only moderately. The vertebrae are affected less severely than the extremities. Severe crippling does not occur. The root of the nose is not depressed, and the intelligence is almost always normal. Helweg-Larsen and Mørch call this group "Silverskiöld's syndrome"; Cocchi refers to it as "type Léri".

Group 2: Sex-Linked Inheritance. In 1939, Jacobsen described a large family in which a mild form of Morquio's disease affected 20 males in 5 generations. The trait was transmitted through females, who themselves were unaffected.

Group 3: Autosomal Recessive Inheritance. The remaining group of families consists of normal parents with one or more affected children. Cocchi collected 125 such families with 184 affected children. He calls this group "type Morquio." Statistic analysis with the standard technics of human genetics showed that the ratio of affected to normal children conformed well to the expected ratio for autosomal recessive inheritance. The high rate of parental consanguinity strongly supported the conclusion. Helweg-Larsen had reached a similar conclusion before However, the importance of mathematic ratios in small and biased samples should not be overrated. The group is not necessarily uniform. Some of the isolated cases may well be due to dominant genes and represent new mutations. The presence of dominant mutants may be suspected on the following grounds: nature selects intensely against abnormal dominant genes, while rare recessive genes are well protected against selection because most of them occur in healthy heterozygotes. Abnormal dominant genes would soon die out if their numbers were not replenished constantly by new mutations.

Recently Mørch analyzed this mechanism in achondroplasia, which is also inherited as a dominant trait.[32] He showed that the achondroplastic gene was derived in only 10 to 20 per cent of the cases from affected parents; in the remaining cases it was due to new mutations. The severe selection against achondroplasia is explained partly by the deformed female pelvis. However, unquestionably there is some natural and presumably also some sexual selection against the dominant Morquio gene too. This is also suggested by the fact that in only two of the above-mentioned 13 families could the trait be traced for three generations and in none beyond three. Cocchi also noted that the group with recessive inheritance had a significant excess of males over females. One could explain at least part of this excess, as others have done, by assuming that Group 3 contains some sibships with sex-linked recessive inheritance. There are simple mathematic tests for verifying this hypothesis (in a suitably large sample), but apparently they have not yet been applied to the material.

THE INHERITANCE OF GARGOYLISM

The genetics of gargoylism are somewhat similar. The data in the great majority of families suggest autosomal recessive inheritance. The high rate of parental consanguinity (14% in Cocchi's review) supports the conclusion. Since gargoylism, like Morquio's disease, is more common in males, the occurrence of a sex-linked variant was suspected. The existence of such a sex-linked form with distinct clinical features

and a somewhat more benign course has since been well substantiated.[31,38] Inheritance through a dominant gene was described recently too,[11] but the conclusion was based entirely on a single family photograph, which was not reproduced in the article.

THE SIGNIFICANCE OF CONSANGUINITY IN RECESSIVE INHERITANCE

To readers not familiar with human genetics, the great significance of parental consanguinity will be illustrated in detail by the following sample calculation:

Let us say that Morquio's disease is due to the abnormal recessive gene x, its counterpart being the normal gene X. Carriers of the Morquio gene have the genetic constitution Xx; affected individuals, xx. Let us now assume that the Morquio gene occurs in the general population with the frequency $p = 1{:}1{,}000$. The frequency of xx individuals, then, would be $p^2 = 1{:}1{,}000{,}000$ and the frequency of the Xx carriers $2p(1-p) = 1{:}500$.

Let us further assume that we are dealing with a population of 100 million. The number of xx individuals in this group would be 100 (actually less, since the xx individuals have a higher mortality than the general population). Further, we estimate the frequency of first-cousin marriages in this population as 0.1 per cent. (For purposes of this study all degrees of consanguinity can be expressed as percentage of first-cousin marriages.) We know that the chances of any parent's being an Xx individual are 1:500. If random mating prevails, his chance of choosing an Xx mate is also 1:500. But first cousins have ⅛ of their genes in common. Thus, if an Xx individual marries his first cousin, his chances of selecting an Xx mate increase from 1:500 to 1:8, i.e., 62.5 times the former figure. In our model population of 100 million, 0.1 per cent, or 100,000, would be offspring of first-cousin marriages. This relatively small group would produce $0.1 \times 62.5 = 6.25$ cases, or 6.25 per cent, of all the affected individuals in the entire population. The general relationship now is readily apparent; the rarer the recessive gene and the higher the frequency of consanguineous marriage in the population, the higher the incidence of parental consanguinity among those afflicted with the disease in question.

The figures assumed here are probably not very far off, perhaps by no more than a factor of two. A gene frequency of 1:2,000 would yield 25 affected per 100 million and 12.5 per cent derived from consanguineous matings, perhaps somewhat more likely figures. Whiteside and Cholmeley[47] found 12 per cent of their cases derived from consanguineous matings. Cocchi[8] found consanguinity in 8 per cent of the presumably recessive group. The actual frequency of first-cousin marriages in the general population is not well known. Neel and Schull[37] give a rate of 0.1 per cent for Caucasians. The present rate in the United States is probably lower, but in certain parts of the world consanguineous marriage is much more common, and it is interesting to note that numerous cases of Morquio's disease recently were reported from the Near East and Africa,[15,29,44,45] regions in which consanguineous matings often are preferred by tradition.

RELATIONSHIP OF MODE OF INHERITANCE TO CLINICAL SYNDROMES

Different modes of inheritance for apparently identical traits or diseases are not uncommon in man. Dominant, sex-linked recessive and autosomal recessive inheritance are known for optic atrophy, retinitis pigmentosa, peroneal muscular dystrophy and some other diseases.[17,37] Frequently there is a relationship among mode of inheritance, severity of illness and age of onset. As a rule, the dominant form is the mildest; the sex-linked, intermediate; and the autosomal recessive, the most severe or earliest in onset. The above-mentioned observations on Mor-

quio's disease agree quite well with this general rule.

The dominant and the recessive forms are due presumably to different genes (and, thus, to different metabolic defects). It is quite unlikely that the same gene is dominant in some and recessive in other families. Since there are considerable differences between some of the families in which the disease is inherited as a dominant trait, it is quite conceivable that there are several dominant Morquio genes. Such genes may or may not be alleles.

The family with sex-linked inheritance described by Jacobsen[26] also showed a relatively mild form of Morquio's disease. It may be worth while to restudy this family, as well as some of the Morquio sibships that contain only males. Such a study will perhaps be rewarded, as in gargoylism (see pp. 148 & 149), by the discovery of a distinct clinical syndrome characteristic of the sex-linked form.

Now to the autosomal recessive form of Morquio's disease! Are the interfamily variations better explained by a set of independent recessive genes, by a series of alleles or by some other mechanism? And what is the best hypothesis for the relationship between Morquio's disease and gargoylism? The answers given here are based on rather indirect reasoning and are highly speculative.

If one assumes that the different forms of Morquio's disease are accounted for by different recessive genes x, y, z, etc., located at different loci, the trait would be found only in xx, yy and zz individuals. The gene combinations xy, xz and yz probably would be phenotypically normal, since different genes control different metabolic processes, and each abnormal gene is counterbalanced by a normal one The separate frequencies f_x, f_y and f_z would have to be smaller than their sum (the frequency of a single gene accounting for all cases). Therefore, the greater the number of independent genes, the higher the expected rate of parental consanguinity. The available data probably are not precise enough for statistic treatment based on this reasoning. However, the following would seem to be a conservative statement: parental consanguinity in recessive Morquio's disease is about as common as in gargoylism. Since Morquio's disease seems to be somewhat less common than gargolyism, it is unlikely that it is due to a larger number of independent genes.

On the other hand, if one assumes that the different forms are due to alleles, x_1,x_2,x_3, etc., all involved in the same metabolic process, one would expect not only the homozygotes x_1x_1, x_2x_2 and x_3x_3 to be affected but also the heterozygous combinations x_1x_2, x_1x_3 and x_2x_3. One would expect different clinical manifestations, different degrees of severity and different ages of onset to reflect the various gene combinations. In either case* one would expect intrafamily variations to be small compared with interfamily differences. One might speculate whether or not "typical" gargoylism represented one of such a series of allelic genes.

An analogous situation is found in the inheritance of the abnormal hemoglobins responsible for sickle-cell anemia and related disorders.[24,35,36] In these disorders investigation is easier because the abnormal genes can be identified in the heterozygote, which, unfortunately, is not yet possible in Morquio's disease or gargoylism. Very likely some of the hemoglobin genes are alleles, others not.[24,36] Clinical disease requires two abnormal genes, identical or allelic, and the severity of the anemia depends on the gene combination.

Jackson,[25] who credits Gates,[17] has proposed an entirely different theory to account for the great variety and the overlapping of clinical syndromes in the hereditary epiphyseal disorders. He assumes that the genes for various skeletal disorders are arranged in close sequence on one of the chromosomes.

* The alternative hypotheses are not mutually exclusive There could well be two or more loci wi[illegible] alleles at each.

During cell division, chromosomes may break and recombine in such a manner that small chromosome fragments containing a few adjacent loci (gene sites) may become lost. Under this hypothesis these skeletal disorders would be due to the absence of the normal genes rather than the presence of mutant genes.

This theory has certain attractive features. Moreover, recent work on the rh genes[33] strongly suggests that closely related genes may actually be located in close proximity and that fragments containing a few loci can occasionally become lost. However, it is unlikely that this hypothesis accounts for more than a rare, exceptional situation because:

1. Abnormalities are due much more commonly to mutant genes than to chromosome defects (at least in animals and plants where these facts can be ascertained).

2. As a rule, the defects produced by chromosome abnormalities are dominantly inherited (at least in the fruit fly), while most of the diseases under consideration here are due to recessive genes.

3. Disease pictures with almost identical features are reported from widely separated places and in different races. This would presuppose that identical chromosome defects would repeat themselves, which seems rather unlikely.

However, there are multiple defects due to more than one gene for which a more obvious explanation is available: there is likely to be a fortuitous recombination of two or more abnormal recessive genes in the offspring of consanguineous matings (Morquio's disease and blindness, Morquio's disease and mental deficiency, etc.). Such associated defects should not be interpreted as rare manifestations of Morquio's disease.

CONCLUDING THOUGHTS ON CLASSIFICATION AND NOMENCLATURE

While it is very likely that the dominant and the recessive forms of Morquio's disease are distinct diseases, as yet the differentiating features are not distinct enough to permit reliable classification of individual cases. In these circumstances it seems premature to replace old terms with new labels, such as "Silverskiöld's syndrome." Since there is considerable doubt as to whether or not "Morquio's disease" is a justifiable disease entity, it would seem to be desirable to agree on a term that covers both Morquio's disease and gargoylism. The German term *polytopic enchondral dysostosis* serves this purpose except for its length and the fact that "polytopic" implies multiple rather than general involvement. *Osteochondrodystrophy* is briefer and would be preferable if used to include gargoylism; at least until the identification of the biochemical defects warranted a new classification. There should be no objection to using "Morquio-type" in parenthesis for those cases which at the time of examination showed none of the visceral signs of gargoylism, so long as it was understood that the secondary term was descriptive rather than differential diagnostic.

During the past decade very few cases of Morquio's disease have been published in the American literature. One can only speculate on the reasons. It could be due to the fact that on close examination and careful follow-up, most of the suspected cases have turned out to be cases of gargoylism; or it could be that it has been felt that Morquio's disease has been described adequately and is no longer medical news. It is hoped that this article will correct the latter impression and encourage additional case reports. Many aspects of the problems discussed here could be resolved with presently available research tools.

The hereditary metabolic disorders have aptly been called "experiments of nature." They are keys to the understanding of normal physiology and metabolism; therefore, their importance is quite out of proportion to the small number of unfortunate individuals afflicted by them.

quio's disease agree quite well with this general rule.

The dominant and the recessive forms are due presumably to different genes (and, thus, to different metabolic defects). It is quite unlikely that the same gene is dominant in some and recessive in other families. Since there are considerable differences between some of the families in which the disease is inherited as a dominant trait, it is quite conceivable that there are several dominant Morquio genes. Such genes may or may not be alleles.

The family with sex-linked inheritance described by Jacobsen[20] also showed a relatively mild form of Morquio's disease. It may be worth while to restudy this family, as well as some of the Morquio sibships that contain only males. Such a study will perhaps be rewarded, as in gargoylism (*see* pp. 148 & 149), by the discovery of a distinct clinical syndrome characteristic of the sex-linked form.

Now to the autosomal recessive form of Morquio's disease! Are the interfamily variations better explained by a set of independent recessive genes, by a series of alleles or by some other mechanism? And what is the best hypothesis for the relationship between Morquio's disease and gargoylism? The answers given here are based on rather indirect reasoning and are highly speculative.

If one assumes that the different forms of Morquio's disease are accounted for by different recessive genes x, y, z, etc., located at different loci, the trait would be found only in xx, yy and zz individuals. The gene combinations xy, xz and yz probably would be phenotypically normal, since different genes control different metabolic processes, and each abnormal gene is counterbalanced by a normal one The separate frequencies f_x, f_y and f_z would have to be smaller than their sum (the frequency of a single gene accounting for all cases). Therefore, the greater the number of independent genes, the higher the expected rate of parental consanguinity. The available data probably are not precise enough for statistic treatment based on this reasoning. However, the following would seem to be a conservative statement: parental consanguinity in recessive Morquio's disease is about as common as in gargoylism. Since Morquio's disease seems to be somewhat less common than gargolyism, it is unlikely that it is due to a larger number of independent genes.

On the other hand, if one assumes that the different forms are due to alleles, x_1,x_2,x_3, etc., all involved in the same metabolic process, one would expect not only the homozygotes x_1x_1, x_2x_2 and x_3x_3 to be affected but also the heterozygous combinations x_1x_2, x_1x_3 and x_2x_3. One would expect different clinical manifestations, different degrees of severity and different ages of onset to reflect the various gene combinations. In either case* one would expect intrafamily variations to be small compared with interfamily differences. One might speculate whether or not "typical" gargoylism represented one of such a series of allelic genes.

An analogous situation is found in the inheritance of the abnormal hemoglobins responsible for sickle-cell anemia and related disorders.[24,35,36] In these disorders investigation is easier because the abnormal genes can be identified in the heterozygote, which, unfortunately, is not yet possible in Morquio's disease or gargoylism. Very likely some of the hemoglobin genes are alleles, others not.[24,36] Clinical disease requires two abnormal genes, identical or allelic, and the severity of the anemia depends on the gene combination.

Jackson,[25] who credits Gates,[17] has proposed an entirely different theory to account for the great variety and the overlapping of clinical syndromes in the hereditary epiphyseal disorders. He assumes that the genes for various skeletal disorders are arranged in close sequence on one of the chromosomes.

* The alternative hypothyses are not mutually exclusive. There could well be two or more loci with multiple alleles at each.

During cell division, chromosomes may break and recombine in such a manner that small chromosome fragments containing a few adjacent loci (gene sites) may become lost. Under this hypothesis these skeletal disorders would be due to the absence of the normal genes rather than the presence of mutant genes.

This theory has certain attractive features. Moreover, recent work on the rh genes[39] strongly suggests that closely related genes may actually be located in close proximity and that fragments containing a few loci can occasionally become lost. However, it is unlikely that this hypothesis accounts for more than a rare, exceptional situation because:

1. Abnormalities are due much more commonly to mutant genes than to chromosome defects (at least in animals and plants where these facts can be ascertained).

2. As a rule, the defects produced by chromosome abnormalities are dominantly inherited (at least in the fruit fly), while most of the diseases under consideration here are due to recessive genes.

3. Disease pictures with almost identical features are reported from widely separated places and in different races. This would presuppose that identical chromosome defects would repeat themselves, which seems rather unlikely.

However, there are multiple defects due to more than one gene for which a more obvious explanation is available: there is likely to be a fortuitous recombination of two or more abnormal recessive genes in the offspring of consanguineous matings (Morquio's disease and blindness, Morquio's disease and mental deficiency, etc.). Such associated defects should not be interpreted as rare manifestations of Morquio's disease.

CONCLUDING THOUGHTS ON CLASSIFICATION AND NOMENCLATURE

While it is very likely that the dominant and the recessive forms of Morquio's disease are distinct diseases, as yet the differentiating features are not distinct enough to permit reliable classification of individual cases. In these circumstances it seems premature to replace old terms with new labels, such as "Silverskiöld's syndrome." Since there is considerable doubt as to whether or not "Morquio's disease" is a justifiable disease entity, it would seem to be desirable to agree on a term that covers both Morquio's disease and gargoylism. The German term *polytopic enchondral dysostosis* serves this purpose except for its length and the fact that "polytopic" implies multiple rather than general involvement. *Osteochondrodystrophy* is briefer and would be preferable if used to include gargoylism; at least until the identification of the biochemical defects warranted a new classification. There should be no objection to using "Morquio-type" in parenthesis for those cases which at the time of examination showed none of the visceral signs of gargoylism, so long as it was understood that the secondary term was descriptive rather than differential diagnostic.

During the past decade very few cases of Morquio's disease have been published in the American literature. One can only speculate on the reasons. It could be due to the fact that on close examination and careful follow-up, most of the suspected cases have turned out to be cases of gargoylism, or it could be that it has been felt that Morquio's disease has been described adequately and is no longer medical news. It is hoped that this article will correct the latter impression and encourage additional case reports. Many aspects of the problems discussed here could be resolved with presently available research tools.

The hereditary metabolic disorders have aptly been called "experiments of nature." They are keys to the understanding of normal physiology and metabolism; therefore, their importance is quite out of proportion to the small number of unfortunate individuals afflicted by them.

SUMMARY

1. The morphologic, the roentgenologic and the clinical features of Morquio's disease have been reviewed. The great variability of the disease has been stressed.

2. The difficulties of differentiating Morquio's disease from gargoylism have been discussed.

3. The genetics of Morquio's disease and gargoylism have been explained in detail. Various hypotheses have been advanced and discussed in the hope of throwing some light on the heterogeneity of the reported cases and of arriving at a better system of classification.

4. Certain suggestions regarding nomenclature are offered.

5. The need for further case reports is emphasized.

REFERENCES

1. Barnett, E. J.: Morquio's disease, J. Pediat. 2:651, 1933.
2. Böcker, E.: Zur Erblichkeit der Dysostosis multiplex, Ztschr. Kinderh. 63:688, 1942.
3. Brailsford, J. F.: Chondro-osteo-dystrophy, Am. J. Surg. 7:404, 1929.
4. ———: Chondro-osteo-dystrophy, J. Bone & Joint Surg. 34B:53, 1952.
5. Brown, D O , and MacDonald, C.: Familial dystrophy (Morquio's disease); 3 cases, Australian & New Zealand J. Surg. 3:78, 1933.
6. Caffey, J.: Gargoylism (Hunter-Hurler disease, dysostosis multiplex, lipochondrodystrophy); prenatal and neonatal bone lesions and their early postnatal evolution, Bull. Hosp. Joint. Dis. 12:38, 1951.
7. ———. *Pediatric X-ray Diagnosis, ed 3*, Chicago, Year Book Pub , 1957.
8 Cocchi, U.· Polytope erbliche enchondrale Dysostosen, Fortschr. Geb. Röntgenstrahlen 72:435, 1950.
9. Cohen, M. M., and Garn, S. M : Factors in occlusion, Am. J. Orthodontics 40:671, 1954
10 Crawford, T.: A case of Morquio's disease, Arch. Dis. Childhood 14:70, 1939
11. David, B.. Über einen dominanten Erbgang bei einer polytopen enchondralen Dysostose (Pfaundler-Hurlersche Krankheit), Ztschr. Orthop. 84:657, 1954.
12. Drysdale, J. H : An undescribed form of dwarfism associated with a spatulate condition of the hands, Quart. J. Med. 1:103, 1908.
13. Eichenberger, K.: Kann die Dysostosis Morquio als selbständiges Krankheitsbild von Gargoylismus abgetrennt werden? Ann. paediat. 182:107, 1954.
14. Einhorn, N. H., Moore, J. R , and Rowntree, L. G.: Osteochondrodystrophia deformans (Morquio's disease); observations at autopsy in one case, Am. J. Dis. Child. 72:536, 1946.
15. Feldman, N., and Davenport, M. E.: Osteochondrodystrophia deformans (Morquio-Brailsford disease), Arch. Dis. Childhood 26:279, 1951.
16. Garn, S. M., and Hurme, V. O : Dental defects in siblings afflicted with Morquio's disease, Brit. Dent J. 93:210, 1952.
17. Gates, R. R.: Human Genetics, New York, Macmillan, 1946.
18. Giraud, G., and Bert, J. M.: La dystrophie osseuse de Morquio dans le cadre des hyperlaxités familiales, Rev. neurol. 63:845, 1935.
19. Grudzinski, Z.: Über eine neue mit Achondroplasie verwandte Krankheitsform, Fortschr. Geb. Röntgenstrahlen 38:873, 1928.
20. Helweg-Larsen, H. F., and Mørch, E. T.: Genetic aspects of osteochondrodystrophy, Silfverskiöld's and Morquio's syndromes, Acta path. et microbiol. scandinav. 22:335, 1945.
21. Hisch, I. S.: Generalized osteochondrodystrophy: The eccentrochondroplastic form, J. Bone & Joint Surg. 19:297, 1937.
22. Hunter, C.: A rare disease in two brothers, Proc. Roy. Soc. Med 10:104, 1917.
23. Hurler, G.: Über einen Typ multipler Abartungen, vorwiegend am Skelettsystem, Ztschr. Kinderh. 24:220, 1919.
24. Itano, H. A.: Qualitative and quantitative control of adult hemoglobin synthesis—multiple allele hypothesis, Am. J. Human Genet. 5:34, 1953.
25. Jackson, N. P U.: An irregular familial chondro-osseous defect with suggestions concerning nomenclature of the generalized osseous dystrophies, J. Bone & Joint Surg. 33B:420, 1951.
26. Jacobsen, A. W.: Hereditary osteochondrodystrophia deformans: a family with 20 members affected in 5 generations, J.A.M.A. 113:121, 1939.
27. Jervis, G. A.: Gargoylism: study of 10 cases with emphasis on the formes frustes, Arch Neurol & Psychiat 63:681, 1950.
28. McKusick, V. A : Heritable Disorders of Connective Tissue, St. Louis, Mosby, 1956.

29. Mahmoud, M. E. S.: Three cases of chondro-osteodystrophy in 2 brothers and 1 sister, J. Egyptian M.A. 37:199, 1954.
30. Marcos, J. R., and Pieroni, L. A.: Enfermedad de Morquio, Pediatria de las Américas 2:726, 1944.
31. Millman, C. G., and Whittick, J. W.: Sex-linked variant of gargoylism, J. Neurol. Neurosurg. & Psychiat. 15:253, 1952.
32. Mørch, E. T.: Chondrodystrophic dwarfs in Denmark, Opera ex domo biologiae hereditariae humanae Universitatis Hafniensis 3:200, Copenhagen, Munksgaard, 1941.
33. Morquio, L.: Sur une forme de dystrophie osseuse familiale, Arch de méd d. enf. 32:129, 1929.
34. ———: Sur une forme de dystrophie osseuse familiale, Arch. méd. enf. 38:5, 1935.
35. Neel, J. V.: Implications of some recent developments in hematological and serological genetics, Am. J. Human Genet. 6:208, 1954.
36. ———: The genetics of blood, *in* Pediatric Clinics of North America, p. 325, Philadelphia, Saunders, 1957.
37. Neel, J. V., and Schull, W. J.: Human Heredity, Chicago, Univ. Chicago Press, 1954.
38. Njå, A. A.: Sex-linked type of gargoylism, Acta paediat. 33:267, 1945, 1946.
39. Race, R. R., and Sanger, R.: Blood Groups in Man, Oxford, England, Blackwell, 1950.
40. Reilly, W. A.: The granules in the leukocytes in gargoylism, Am. J. Dis. Child. 62:489, 1941.
41. Reilly, W. A., and Lindsay, S.: Gargoylism (lipochondrodystrophy), Am. J. Dis. Child. 75:595, 1948.
42. Russo, P. E.: Chondro-osteodystrophy (Morquio's disease); case observed during pregnancy, Radiology 44:42, 1943.
43. Shelling, D. H.: Osteochondrodystrophia deformans (Morquio's disease) *in* Brenneman's Practice of Pediatrics, Hagerstown, Md., Prior.
44. Sinna, I. A.: Chondro-osteodystrophy with case report, J. Egyptian M.A. 37:177, 1954.
45. Townsend-Coles, W. F.: A report of 7 cases of chondro-osteodystrophy (Morquio's disease), Arch. Dis. Childhood 29:7, 1954.
46. Wheeldon, T. F.: A study of achondroplasia, Am. J. Dis. Child. 19:1, 1920.
47. Whiteside, J. D., and Cholmeley, J. A.: Morquio's disease: review of the literature with a description of 4 cases, Arch. Dis. Childhood 27:487, 1952.
48. Zellweger, H, Giaccai, L., and Firzli, S.: Gargoylism and Morquio's disease, Am. J. Dis. Child. 84:421, 1952.

Morbo de Morquio

Summario in Interlingua

Un breve introduction historic a morbo de Morquio e a gargolismo e un discussion del nomenclatura es sequite per un description detaliate de morbo de Morquio. Le autor presenta un revista del apparentia general, del constatationes radiologic, del datos laboratorial, del materiales pathologic, del curso clinic, e del resultato final. Radiographias e photographias representative accompania le texto.

Es suggerite que morbo de Morquio es causate per un hereditari defecto metabolic, probabilemente un deficientia in le production de un sol enzyma individual.

Le variabilitate del tableau clinic e su grande similitate a gargolismo es sublineate. Un differentiation definitive inter morbo de Morquio e gargolismo non es possibile in omne casos.

In le spero de clarificar certes de iste vexante problemas, le autor examina e discute in detalio le genetica de morbo de Morquio e de gargolismo. Esseva facite un effortio a presentar iste material in un forma que es facile a comprender per non-geneticistats. Varie hypotheses alternative es offerite pro explicar le datos colligite. Le meritos de iste hypotheses es discutite.

Le paucitate de reportos recente in re morbo de Morquio es deplorabile. Ben que le complete clarification de morbo de Morquio debe attender le discoperta del specific anormalitate biochimic in question, multe importante problemas in iste campo esserea sin dubita resolvibile super le base de ben documentate reportos de cautemente studiate casos additional.

18

Juvenile Osteochondroses—Enchondral Dysostoses*

HANS MAU, M.D.

For many years the etiology of aseptic necroses or juvenile osteochondroses has been the subject of much study. Many theories have been advanced and discussed extensively during the years without one hypothesis being generally accepted. However, with a better understanding of the nature of the hereditary cartilage-ossification disturbances, of the so-called enchondral dysostoses, it became possible to discern more clearly the constitutional factor in the origin of many cases of juvenile osteochondroses. The following clinical and roentgenologic observation may serve as a basis for our studies on this subject.

CASE REPORT

Thomas H., 8½ years old, born March 24, 1945. Height 115 cm. (10 cm. below the expected height). A vivacious, co-operative boy with slightly bulging forehead and flaring of the short costal arch, pronounced increase of the lumbar lordosis, relatively short thighs and coarse-shaped hands, the forearms also both clinically and roentgenologically slightly too short when compared with the length of the upper arms. The right arm is 2.5 cm , the right leg 1.5 cm., longer than the corresponding extremity. This difference in length should be ascribed possibly to the existence of a hemangiomatosis and venectasia, chiefly on the right side of the body (Fig. 1).



FIGS. 1 to 5, same patient. FIG. 1 (*Above*). At 8½ years of age Hemangiomatosis and venectasias Forearms, hands and thighs slightly shorter than normal. Pronounced lordosis.

* From the Orthopaedic Hospital of the University of Heidelberg (Director: Prof. K. Lindemann).

Without apparent cause slight limping with the right leg occurred for the first time at the age of 2½ years; at the age of 3½ years a diagnosis of right-sided Legg-Calvé-Perthes syndrome was made (October 12, 1948). *Roentgenologically* there was patchy rarefaction with increased density of the right capital epiphysis. Left femur head was practically normal (Fig. 2).

[illegible]

head had increased distinctly in size, but on the left side it had become smaller, and there was total initial sclerosis—in short, developing Legg-Calvé-Perthes syndrome. October, 1949: left side florid Legg-Calvé-Perthes syndrome with circumscribed sclerosis, patchy destruction and flattening of the femur head, whereas the right capital epiphysis had continued to grow and became higher. The patient was placed in a plaster cast in abduction.



Fig. 2. At 3½ years of age. Typical Legg-Calvé-Perthes syndrome, right side.

September, 1950. Right capital epiphysis had developed normally and showed only slight residual flattening. On the left side, however, when compared with the right, there was progressive destruction (Fig. 3). A Thomas splint then was applied to the left side. With this the now quite flat left capital epiphysis gradually grew in size. On the right side the capital epiphysis again narrowed slightly. The final result is that both proximal femur ends became increasingly blunt with broadening of their shape and with foci of destruction also in the metaphysis, as shown when x-rayed in Lauenstein's position. Gradually the use of the splint was discontinued.

October, 1953. Relatively small iliac bones, right capital epiphysis flattened but of normal structure. On both sides the epiphyseal lines were still open. On the left side there was marked and irregular flattening and broadening of the epiphysis; its disorderly structure clearly demonstrated that the destructive process was not quite closed. Widening of the metaphysis was more pronounced on the left side. The left acetabulum was slightly shallower than the right (Fig. 4).

Hand: coarsely shaped and short; ossification

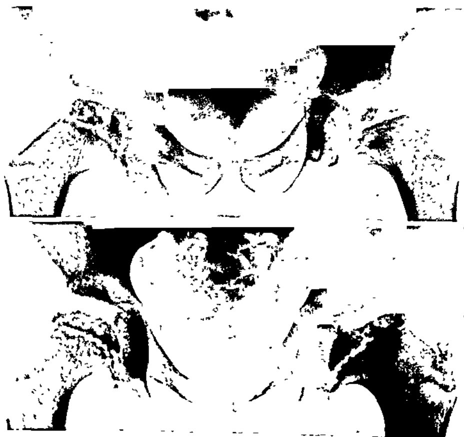


Fig. 3. At 5½ years of age. Femoral head on right side completely restored, left-sided Legg-Calvé-Perthes syndrome.

Fig. 4 At 8½ years of age. Right femoral head slightly flattened again, left side moderate healing.



FIG. 5. At 8½ years of age. Pronouncedly broad, short hand with structural changes, especially in the distal radius, wide epiphyseal line in the distal ulna, the short phalanges of the fingers present a gross reticular structure.

of the carpal bones delayed There was gross atrophy of the spongiosa structure, irregular outline of all epiphyseal lines; the distal radius metaphysis was particularly deformed and showed an increased deposition of calcium. The epiphyseal line of the distal ulna was wide (Fig. 5).

Lateral projection of the spine: indication of lumbodorsal kyphosis, whereas the remaining part was straight Slight concavity of the dorsal parts of the end plates. Only slight flattening of the vertebral bodies. The closing of the vertebral arches was not quite complete in the lower segment of the thoracic spine.

EPICRISIS

Description of an early typical Legg-Calvé-Perthes syndrome involving first one and then the other side, ultimately resulting in restoration of the bone in a boy who doubtless presented general disturbances of cartilage ossification, especially in the hands and, therefore, should be diagnosed as a form of enchondral dysostosis. At the same time there was an extensive hemangiomatosis, predominantly one sided. If in this case the initial restoration of the femoral head were followed by unilateral flattening of the head, this probably should be explained as follows: due to bilateral involvement and in spite of the plaster cast treatment in abduction, continued over many months, weight-bearing had been allowed too early. Another old rule was confirmed once more in this case: restoration of the femoral head is more successful in the younger patients

In our opinion, this observation furnished proof, which until now had always been a moot point, that even in the case of enchondral dysostosis a bone that was roentgenologically normal, in this case a femoral head, may be restored to a large extent when involved in a Legg-Calvé-Perthes syndrome. The unusual factor in this case, therefore, is that due to its other skeletal symptoms it occupies an intermediary position between an ordinary Legg-Calvé-Perthes syndrome with its radiologically unchanged femoral head before the onset of the disease and the severe enchondral dysostoses with their primarily disturbed formation of the femoral head.

It would seem to be useful to define certain concepts before proceeding to further discussion.

JUVENILE OSTEOCHONDROSES

Under this heading we group the developmental disturbances in the cartilaginous epiphyseal and apophyseal centers and also in the independent small bones. In the first place there occur during the growth period the Legg-Calvé-Perthes syndrome, Köhler's disease of the os naviculare pedis, Osgood-Schlatter disease of the tibial apophysis, the apophysitis calcanei, and also the juvenile kyphoses (Scheuermann), osteochondrosis dissecans, as well as the more rare localiza-

tions like malacia of the tip of the patella (Sven Johansson-Sinding Larsen) or of the capitulum humeri (Panner).

The concept of juvenile osteochondroses is more and more accepted, as opposed to those terms formerly in use, such as aseptic necroses, local malacia, chondro-osteonecroses, avascular necroses and juvenile osteochondropathies. This is as it should be, since necrosis is not always part of the picture, as we were able to demonstrate by means of personal cases in which the diagnosis was confirmed by histologic examination. Necrosis of the growing epiphysis is only a phase of a much more extensive pathologic process (Lindemann).

By the recent inclusion of certain syndromes which were formerly not so classified, such as Thiemann's disease of the fingers, or even Madelung's deformity, osteochondrosis tibiae deformans, etc. (Goff), the concept of juvenile osteochondrosis has been essentially enlarged as against that of aseptic necrosis, but the enlargement is predominantly in a certain direction, that of the enchondral dysostoses. Consequently, there is a certain overlapping, which will be demonstrated later.

ENCHONDRAL DYSOSTOSES

The concept and the nature of enchondral dysostoses has been sharply outlined only in recent years. By enchondral dysostosis is meant a disturbance of the cartilage ossification on a congenital basis, syndromes which until now had been described either as atypical chondrodystrophy, osteochondrodystrophy, Morquio's or Brailsford's disease, or as multiple epiphyseal disturbances, spinal dwarfism, Ribbing's disease, etc. In the first group, growth of both epiphyses and metaphyses is disturbed, whereas in the second group the disturbance is confined chiefly to the epiphyses. On the basis of more than 50, at the moment over 75, personal observations of partly familial cases, it was shown that the classic chondrodystrophy (achondroplasia) and chondrodystrophia calcificans congenita should be included as a pecul[illegible] type of pathologic ossification variation. T[illegible] also holds true for the localized symmet[illegible] forms, for the rarer asymmetric forms a[illegible] especially for the light forms. This wid[illegible] considerably the concept of enchondral d[illegible]ostosis, which becomes the prototype of enchondral ossification disturbances.

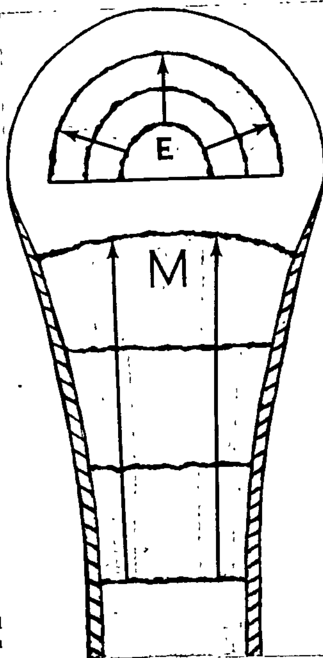


FIG. 6. Diagram of the normal enchondral metaphyseal longitudinal and epiphyseal center growth. The distance between the transverse lines in the metaphyseal area (M), the semicircles in the epiphyseal areas (E), and the arrows indicate the different growth rates and direction in both areas.

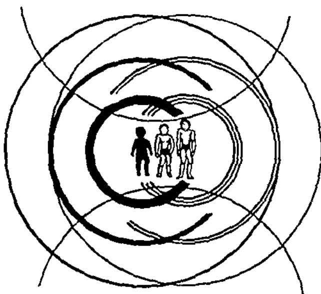


FIG. 7. Schematic drawing of the various enchondral dyostoses. This figure illustrates the relations between metaphyseal and epiphyseal growth disturbances, which are widely overlapping. In the center of the left circle is shown a case of chondrodystrophy (achondroplasia), in that of the circle on the right a spinal dwarf; in between these two is the *not very striking figure* of the "third man," well proportioned and only slightly dwarfed, representing the majority. Inner circle: severe form. Middle circle: mild form. Outer circle: constitutional disposition. Endogenous and *exogenous influences*, which can lead to mixed types, are represented by the upper and the lower semicircles. (Based on a schematic drawing by W. Marquardt)

This widening of the group seems to be efficient, since no sharp differentiation is possible between the clinical manifestations of disturbed *metaphyseal longitudinal growth* on the one hand and disturbance of *growth in epiphyseal ossification centers* on the other (Fig. 6). On the one hand we have the patient with chondrodystrophy whose growth disturbance is to be found in the metaphyses and is characterized by a pronounced shortening of the long bones—a sitting giant; on the other, the dwarfed spine with involvement of the epiphyses and the short flat bones, the patient with joint and spine dysplasia—a sitting dwarf. Much more numerous than is generally supposed to be the case are those transitory forms where in one and the same patient metaphyseal and epiphyseal growth disturbances exist side by side (Fig. 7). Intrafamilial variations either in the direction of metaphyseal or of epiphyseal manifestations have been described. Therefore, it is more to the point to use the term *dysostotic group* with, at its extreme ends, the chondrodystrophic and the spinal dwarf.

Most likely chondrodystrophy constitutes a genetically independent trait. In the much larger and varied group of the atypical chondrodystrophies, there may be partial involvement. In contrast with classic chondrodystrophy, we may also find severe cases together with light cases in atypical chondrodystrophy. According to recent investigations, chondrodystrophy is inherited almost exclusively as a dominant trait, but for the second and larger group with epiphyseal involvement, the pathologic trait frequently is inherited as a recessive factor too.

Roentgenologic investigations have shown that even in cases with apparently only partial involvement, there is in reality no localized process; sometimes there are structural disturbances in various other skeletal parts if roentgen examination is continued over a longer period of time and each separate bone is studied closely during its developmental phases. Also, there probably is a certain relationship between the nature of the subsequent ossification disturbance (either predominantly metaphyseal or predominantly epiphyseal) and the process of skeletal development in such a way that, with earlier lesions, the metaphyses are involved in their developmental phase (sensitive phase), while with lesions occurring later the epiphyses are involved predominantly. The apophyses rarely are included.

When compared with normal development, the dysostotic cartilage ossification in the epiphyseal regions is characterized by a late appearance of the epiphyseal centers on the roentgenograms. Only rarely is ossification accelerated or completely lacking. Among the bones which present the epi-

physeal type of ossification, we frequently find involved those which normally would ossify last, such as the navicular bone of hand and foot, the adjacent bones and the patella. *Delayed skeletal maturation on the basis of a primary anlage disturbance is probably the most sensitive indicator of a dysostotic growth disturbance*, especially if "dissociated," i.e., one bone showing delayed skeletal maturation, another one normal maturation.

Further characteristics are *relatively small size of the epiphyseal centers*, trough-shaped defects and dissecting processes. The epiphyses are relatively wider and flatter than normal; *the height/width index is altered in favor of the width*. All proportions of the body have changed in the same direction, and with a predominantly metaphyseal involvement the individuals are increasingly *shorter in height*. Another typical feature is the formation of *accessory bone centers*. A great number of skeletal variations may be observed, which are to be considered typical in certain cases of enchondral dysostoses, such as duplication of centers and multifocal epiphyseal ossifications.

Contrary to general opinion, numerous histologic data already are available, even for the predominantly epiphyseal disturbances. The general syndrome is composed not only of regressive but also of *restorative* processes. In contrast with other morphologic defects of the skeleton, the dysostotic deformities possess a natural healing tendency in the young, dependent on the mechanical stress and the degree of involvement of the biologically inferior bone.

The diseased cartilage often is of an inferior type; therefore, there is an inherent predisposition to vascular disturbances due to constriction of the afferent vessels. These disturbances of circulation are demonstrable only in some cases and usually run a very slow and clinically unobtrusive course. The same condition of the articular cartilage promotes a precocious arthrosis deformans, as was observed on examination of the different members of dysostotic families.

An *etiologic relationship* between enchondral dysostoses and certain cases of entire groups of *orthopaedic diseases* may be discovered by considering them as localized forms and by regarding the greater or the lesser severity of the developmental disturbance in part as manifestations of the influence exerted by the hereditary, constitutional dysostotic factor. Among those the most important for the *spine* are some juvenile kyphoses, wedge-shaped dorsal vertebrae, idiopathic scolioses; for the *hip joint*, coxa vara congenita and the Legg-Calvé-Perthes syndrome; for the *knee joint*, osteochondrosis tibiae deformans (tibia vara), osteochondrosis dissecans, tibia recurvata, fissures in the patella and the congenital and habitual patellar luxation; for the *foot*, Köhler's disease I and hallux rigidus; for the *arm*, humerus varus idiopathicus, Thiemann's disease, Madelung's deformity, the so-called dorsal subluxation of the ulna and the flat hand. The diseases mentioned may present the dysostotic component to a varying degree, but this is not necessarily so in all cases.

MECHANICAL FACTOR

As we have seen, the dysostotic growth disturbance may vary by involving predominantly either the metaphyses or the epiphyses, by being generalized or localized, or by being mild or severe with all gradations. The mildest cases merge into the *dysostotic constitution*. The factor of hereditary constitutional disposition sometimes becomes apparent only by a kind of trigger mechanism, most often a mechanical influence. This may manifest itself chiefly in the epiphyseal area. This holds true with the exception of the femoral neck, for here the metaphysis can be involved also (coxa vara congenita). It is necessary to familiarize ourselves with the notion of *relative* stress. A condition like that arises from a discordance between the weight-bearing (demand) and the static capacity.

It has always been a moot question whether hereditary or exogenous factors play

a decisive part in the development of certain skeletal diseases. These diseases range from the severe endogenous hereditary malformations (for example, aplasia) via less severe congenital dysostotic disturbances (for example, Thiemann's disease) and a constitutional dysostotic disposition through normal and beyond that into the field of static mechanical traumata (fatigue fractures) and on to severe single direct fractures. All studies of the cause of the diseases existing between these two extremes have shown that there is no question here of "either/or" but rather of "this and that." There can be differences of opinion only on the degree and the possible significance of endogenous and exogenous forces. Only on this basis can discussion become fruitful.

In the case described above, we consider the endogenous component to be the decisive one in the development of the femoral head necrosis. On the other hand, it cannot be denied that the necrosis, running a similar course, has been seen as a result of a single trauma during childhood. Here trauma is the essential cause. It is also known that endocrine factors (pituitary, thyroid or gonads) and vascularization disturbances of the epiphyses (air embolus, blood disease, etc.), as well as infectious and metabolic disorders, may be involved in the development of epiphyseal necroses. The roentgenologic and the histologic findings in these cases very often show great similarity, owing to the limited reactivity of the bone. It may be stated in general that in juvenile osteochondrosis a complexity of factors is involved. Therefore, the term *syndrome* is being used increasingly.

ENDOGENOUS FACTORS

We will consider only the endogenous factor in studying the development of juvenile osteochondroses. To all who are of the opinion that general trauma or microtrauma is the most important etiologic factor, we should like to put the question, why, then, do not almost all adolescents develop this disease, since during the first 10 to 14 years of life the mechanical stress in children as opposed to adults is practically the same for all? There is a further question, why do we so rarely find a Legg-Calvé-Perthes syndrome in Polynesians or in Negroes (Goff)? Goff even went so far as to state that a genuine Legg-Calvé-Perthes syndrome rarely was encountered in Negroes. With this statement he places the constitutional factor entirely in the foreground. While visiting the United States, especially the southern states, we looked particularly for this syndrome among the Negroes and found only 1 case in New York, and in this case admixture of white blood might be held responsible insofar as there was no concomitant sickle-cell anemia. However, it should also be borne in mind that the Negro population constitutes only a small fraction of the entire population; therefore, a Legg-Calvé-Perthes syndrome is to be expected only rarely among this group. Nonetheless, it would be surprising if this syndrome did not occur among Negroes, seeing that it may be found even among cows, pigs and horses, whereas severe enchondral dysostoses have also been observed in Negroes.

From these examples it becomes clear that great importance should be attached to the constitutional factor in the development of certain juvenile osteochondroses. The significance of this constitutional disposition was fully understood by Lehmann in 1922, when he suggested the hypothesis of the "constitutionally weak epiphyses." Later its existence and heredity were sharply defined by numerous authors.

Among those greatly interested in the epiphyseal type of enchondral dysostosis, Silfverskiold, Ribbing, W. Müller and others have stressed the close relationship between these cases and those of "aseptic necroses," though without confirming the absolute likeness of both disease groups in the majority of cases. Only with certain localizations has this been done. W. Muller, for instance, tried to include many of the osteochondritis dissecans cases in his group of "multiple epiphys-

cal disturbances." Ribbing saw a close connection between hallux rigidus and "aseptic necroses." But until now no one has arrived at the conclusion that *the constitutional components of many juvenile osteochondroses are to be considered equal to the constitutional disposition of the epiphyseal enchondral dysostoses*. If, in the development of juvenile osteochondrosis, a constitutional factor plays a role at all—and in our opinion this is really the case in many localizations—most probably it is the dysostotic factor. From a clinical as well as from a roentgenologic viewpoint, it is impossible to distinguish clearly between the two groups. There is a gradual transition from the severest forms of epiphyseal dysostosis, via the mild forms, to the initial and fully developed pictures of juvenile osteochondrosis. The severe dysostoses are merely "more than aseptic necroses."

In one and the same patient we have repeatedly and beyond any doubt noticed changes, sometimes very severe ones, indicative of enchondral dysostosis, while simultaneously in other parts of the skeleton there were lesions completely characteristic of juvenile osteochondrosis. This plainly revealed that there had been resorptive processes or that they would shortly develop. We were able to study all phases of the resorption. This destruction may develop as rapidly as in juvenile osteochondrosis and cannot be distinguished from it. Before collapsing, the epiphyses may give rise to completely normal roentgenograms (in spite of a slight dysostotic structural deformity) and then present an initial complete sclerosis with complete destruction, followed by reparative processes. This is our personal observation, and it is by no means an isolated one. Only years later was it recognized in our case described above that enchondral dysostosis was a part of the entire syndrome.

Even in those epiphyses subject primarily to severe dysostosis, the condition is not always irreversible, although generally the process runs a slower course than in juvenile osteochondrosis. In asymmetric cases it may be presumed that slight differences in the severity of structural disturbances, together with mechanical forces, constituted the proverbial straw that broke the camel's back, although the "safety coefficient" had been reduced fairly equally on both sides. The process runs its course unhindered and unaffected on the one side, while treatment, which prevents weight-bearing or brings about complete immobilization, benefits the other side. This period of rest is utilized by the unaffected bone on the opposite side for sufficient reinforcement during this almost equally critical period of its growth. This may prevent a later outbreak of the same disease on this side. From time to time, however, the other side becomes affected—although later when treatment of the side originally affected is completed or when the process reaches its lowest point. Through this time difference on both sides it is often possible to explain a difference in the severity of deformities on the two sides. The frequent occurrence of unilateral juvenile osteochondrosis often is the expression of the receding of the endogenous factor as compared with the more severe type of dysostosis.

Multiple disturbances are not so rare. Many earlier investigators described cases of aseptic necroses or juvenile osteochondrosis affecting several parts of the skeleton in one and the same individual. For instance, osteochondrosis dissecans in the knee joint and the talus (Howald) or generalized osteochondrosis dissecans (W. Müller, Platzgummer and others) has been reported. Brandes, Drehmann, Hanson, Harbin-Zollinger, Perthes and others observed a Legg-Calvé-Perthes syndrome together with juvenile osteochondrosis in other skeletal parts (cited by Ribbing). Many other similar reports have come in, mostly stressing one localization in particular.

A more thorough examination of a few selected cases with juvenile osteochondrosis yielded a few of the less noticeable dysostotic signs. With a peculiar *early development*

of the osteochondrosis in children or with bilateral localizations, skeletal changes in other areas are present occasionally. These cases are characterized simultaneously by slight *retardation* of *skeletal maturation* and slight *dwarfism.* The findings in families apart from those cases described as enchondral dysostosis are also reported in juvenile osteochondrosis. Here especially it is most difficult to make a clear distinction, and especially for those *familial cases* we think that it is permissible to *include them in the group of dysostoses.* These familial cases of juvenile osteochondroses were described (so far as the Legg-Calvé-Perthes syndrome was concerned) by more than 25 authors. We have also been able to observe what was doubtless a familial case. Goff reported on a further 25 personal cases of familial Legg-Calvé-Perthes syndrome. The lesions considered to be dysostotic would probably outnumber the former (Legg-Calvé-Perthes cases) several times, and some of Goff's cases probably belong here.

HISTOLOGY

A study of the histologic picture of juvenile osteochondrosis and related conditions furnishes few data of help in clearing up the relations between juvenile osteochondrosis and an enchondral dysostosis, because the histologic pictures available are *mostly* those of a *late phase,* where resorption is the principal feature. In certain cases of Legg-Calvé-Perthes syndrome, however, several authors were able to demonstrate the presence of columns and strands of cartilage cells in the center of the femoral head spongiosa that they considered to be at least partly the substrate of an endogenous cause of the disease. These heterotopic cartilage and bony islands, together with intermittent edematous swelling of the cartilage matrix, were also seen in other cases of juvenile osteochondrosis, as well as in Schmorl's nodules of the spine, in hallux rigidus and in coxa vara congenita. Burckhardt described similar, if not identical, changes in the Legg-Calvé-Perthes syndrome and in coxa vara congenita.

Osteochondrosis dissecans occupies an exceptional position among these diseases. The juvenile forms are here of very special interest.

With a view to proving his hypothesis of constitutionally weak epiphyses in its relation to osteochondrosis dissecans, Lehmann reported having found islands of cartilage inside the spongiosa reticulum of a joint mouse in its early stage. Conversely, he also observed completely intact bony islands in the hyaline cartilaginous portion of the same joint mouse. The cysts so often found in later stages are supposed to originate in these islands of cartilage.

Finally, it was Ribbing especially who stressed the connection between dissecting processes and aseptic necroses. First he pointed out those sharp protuberances and rough areas often noted in children between 3 and 7 years of age, localized in the distal femoral epiphyses. These were not only on the sides but also on the articular surface. In the histologic specimens besides the real epiphyseal center, small bony islands were noted in the surrounding cartilage showing a normal spongiosa. Blood probably was supplied by an end artery. These peripheral bony islands, occurring excentrally relatively late in the growth period, are found more often in the medial condyle than in the lateral according to Ribbing. He presumes that these bony islands, more or less completely surrounded by cartilage, persist and constitute a locus minoris resistentiae; the small bony pieces are easily shifted and thereby cut off from their blood supply.

The same author was able to remove from the bed of the joint mouse a free body histologically vital with a well-defined cartilage. This was definitely a developing free body. He concludes that the nucleus of bone must have been present primarily, with necrosis and demarcation setting in at a later date. He was able to study such a living accessory bony center roentgenologically for several years and so observe its necrosis and sequestration. Finally it was incarcerated. With this the chain of evidence was completed.

No such studies have been made for the elbow joint so far as we know. The fact that the knee and the elbow joint are the joints by far the most frequently involved is due not only to the peculiar mechanical structure of the joints but also partly perhaps to individual growth, characteristic of the articulation involved, and its blood supply. Although it has been argued that hereditary vascular anomalies play a role in the development of osteochondrosis dissecans, this does not seem very likely, because of the simultaneous occurrence of dissociating and nondissociating dysostotic processes in one and the same patient. However, it cannot be ruled out altogether. At any rate, accessory centers of ossification are common among the group of dysostoses.

There is obviously a close histologic relationship between juvenile osteochondrosis and related disease entities. These histologic findings show a certain resemblance to the histologic picture of milder cases of enchondral dysostoses and various phases of the disease. These problems still need further study.

ROENTGENOLOGY

In a recent study of the roentgenologic aspects of epiphyseal ossification, Liess made the following distinction regarding the aseptic necroses versus juvenile osteochondroses.

1. False appearance of aseptic necrosis, due to accessory bony center formations appearing as a manifestation of abnormal ossification

2. Development of aseptic necrosis on the basis of an accessory bony center formation

In this connection, Forsell's observations of many years ago deserve our attention: in Köhler I he described seeing several bony centers in the navicular on the unaffected side and supposed this to be a locus minoris resistentiae. In similar selected cases, Laurell also saw abnormal ossifications. He used the expression "Status Köhleri," although there is no actual resorption (cited by Ribbing). Similar observations were made by Grashey, Karp and Sauer (cited by Liess).

We also saw similar images in the navicular bone of the foot and in the phalanges. We were most impressed by the disorderly structures of the capital epiphyses, which were slightly flattened before the malacia set in, which in our observation occurred several months later.

These observations furnished significant proof that *bone formation occurring in several centers of different size, as is characteristic of epiphyseal enchondral dysostosis, predisposes to the development of bony necrosis* This is especially true when a few centers do not coalesce completely but persist and are more or less separated from each other by bands of cartilage. This disturbed ossification is not far removed from a beginning ischemic necrosis due to vascular obstruction with ordinary use. The transitions are almost imperceptible, and roentgenologic differentiation at this stage is sometimes impossible.

CLASSIFICATION OF JUVENILE OSTEOCHONDROSES

Harbin-Zollinger divided the osteochondroses into the primary osteochondroses occurring during the first 10 years and the secondary forms of a later period of life. Hirsch, adopting Jaffe's classification, enlarged the concept by contrasting the localized forms with generalized osteochondrodystrophies. The localized forms correspond to ordinary juvenile osteochondrosis, while the generalized types chiefly resemble epiphyseal enchondral dysostosis.

Goff further differentiates the localized forms, thereby following other American authors According to him, "true" juvenile osteochondroses are those in which epiphyses are subject to pressure. He includes the Legg-Calvé-Perthes syndrome, Köhler's disease I and II (Freiberg) and juvenile kyphoses. A hereditary factor is held to be chiefly responsible in this type. A predominantly traumatic origin is presumed in those diseases which involve epiphyseal centers exposed to traction, as, for instance, the tibial tubercle and the calcaneus apophysis, the

patellar apex, the trochanters, the olecranon, etc. These are grouped together with "atavistic epiphyses," as, for instance, the iliac crest, as pseudosteochondrosis in contrast with the "true" osteochondrosis of epiphyseal diseases due to pressure. *Only in cases of "true" juvenile* osteochondrosis did he find dwarfism and delayed maturation of the skeleton at the same time. This classification, representing a predominantly mechanical viewpoint, is a decided step forward. It is based on the now generally accepted theory that epiphyseal and apophyseal centers during their developmental phase, especially during the first years of their formation, are particularly sensitive to mechanical influences.

The study of enchondral dysostoses leads us to a similar conclusion. It appears that "atavistic epiphyses," those apophyseal centers that are the last to ossify, very rarely present a genuine dysostotic structural disturbance. Chronologically they are placed at the end of the ossification series; the scale of possible noxious influences rarely extends so far down the epiphyseal area. If there is a severe and more metaphyseal disturbance, development of the physiologically late-appearing centers may be entirely impossible on this "scourged earth." Between the chronologic extremes of diaphyseal and apophyseal development, all fluent transitions are possible. Goff's "traction epiphyses" are situated between epiphyses and apophyses. In this group familial distribution has been observed, although rarely However, the corresponding growth disturbance is not at all rare in this group, a fact which is generally known. In our opinion, these cases often are, indeed, chiefly exogenous, but not as exclusively so as Goff thinks.

Seiss-Wiesner's observations in 14 cases of Schlatter-Osgood's disease, which showed a general increase of width in the knee epiphyseal centers with simultaneous decrease of the longitudinal dimension (*tibial and femoral* centers and the patella disharmonically, while the capitulum fibulae is not involved), pointed to the participating dysostotic component. The simultaneous presence of juvenile osteochondrosis in other joints often was described for this group when specially examined in that direction. The possibility of hereditary conditioning of these juvenile os*teochondroses was confirmed still further* by the observation of concordant incidence in monovular twins. Therefore, it is necessary to differentiate a little further. It does not seem to be justified to attach the term *pseudosteochondrosis* to those lesions in relatively late-appearing centers. In view of the etiologic evaluation of endogenous and exogenous factors, at least 3 categories should be distinguished:

1. Juvenile osteochondrosis on the basis of a predominantly endogenous dysostotic factor, in which bone necrosis need not necessarily occur in all cases
2. Juvenile osteochondrosis on a mixed dysostotic-mechanical basis (with relatively late-appearing centers when compared with Group 1)
3. Juvenile osteochondrosis on a predominantly exogenous mechanical basis with obligatory bone necrosis
4. Juvenile osteochondrosis on other bases (hormonal, blood diseases, etc.), which are relatively infrequent

Necrosis of the lateral epicondylus humeri, for instance, which ossifies only in the twelfth year of life, *should be included in* Group 3. Such lesions and those of a similar nature are really rare, which is in accordance with our concept of their genesis. The late-appearing lunatum malacia should also be included in the third group, frequently representing a lesion due to work with compressed air. The juvenile osteochondrosis of the heads of the metatarsal bones (Köhler II—Freiberg) often is due chiefly to a mechanical factor, as already indicated by the occasionally simultaneous occurrence of fatigue fracture of the shaft of the second metatarsal bone. However, the *familial, relatively early, multiple and bilateral cases belong to the first group,* they are often associated with signs of *dysostotic delayed skeletal maturation* and with

ossification centers that are *slightly smaller* and *flatter than normal* and with a *moderate dwarfism*. The proposed classification is flexible enough to allow of effortless inclusion of conditions pronouncedly due to dysostosis as well as of those conditions which are the result of unusually marked exogenous influences.

Because of the fluent transition existing among the three groups, any discussion of rigid distinctions between them is useless, since this classification is based simultaneously on the degree of severity of the mechanical influences and on the order in which the bone centers appear. To a certain extent the time element in the epiphyseal and the apophyseal development is linked to the probability that the ordinary juvenile osteochondrosis develops because of the assistance of an endogenous component. *Physiologically early development heightens the chance of involvement of an endogenous dysostotic factor.*

We may summarize the preceding chapters as follows:

In many cases of juvenile osteochondrosis and its preliminary stages, a dysostotic constitutional basis is present. There is not only the difficulty of determining the extent to which the dysostotic component is involved in an individual case but also the necessity of defining the concept of enchondral dysostosis against that of juvenile osteochondrosis. In our opinion, the concept of juvenile osteochondrosis should be restricted to disturbances in the epiphysis and the apophysis, and should include only such cases which present clear-cut evidence of necrosis. Other similar syndromes should be termed *enchondral dysostosis*, especially when characterized by metaphyseal involvement, familial occurrence and absence or near-absence of mechanical factors in their development Here also the transition is fluent.

This is not the place to discuss the various localizations of juvenile osteochondrosis; nor is it suitable to enumerate here the several reasons why involvement of a dysostotic component in the development of each of the above described syndromes is thought to be likely. This has been done in a more extensive review. The purpose of this chapter is only to point out the significance of enchondral dysostosis in regard to the etiology of juvenile osteochondrosis. While studying the etiologic problem, enchondral dysostosis never can be excluded, since in our opinion it constitutes the most frequent hereditary disease of the skeletal system in the animal world as well as in man.

This theoretic discussion also has its *practical value.* In diagnostically difficult cases familial, relatively early and bilateral involvement, accessory epiphyseal ossification centers and multiple foci of ossification, a slight dwarfism and a delayed skeletal maturation which manifests itself by the delayed appearance of the carpal bones in the roentgenograms—all point in the direction of juvenile osteochondrosis of Group 1. If only one side is found to be involved when first the diagnosis of juvenile osteochondrosis is made, the other side should be subjected to a very careful study and treated with the utmost care. This rule is often disobeyed, as is seen in daily practice. Recognizing the possible constitutional dysostotic component of a case of juvenile osteochondrosis is also important in evaluating workmen's compensation cases.

SUMMARY

We have reported a peculiar case of Legg-Calvé-Perthes disease of the hip joint which entailed new etiologic problems.

Following an exposition of the nature of hereditary enchondral dysostosis (atypical chondrodystrophies, osteochondrodystrophies, multiple epiphyseal dysgenesis, etc.), the relationship between its mildest form, the dysostotic constitution, and juvenile osteochondroses (aseptic necroses) is discussed. In juvenile osteochondrosis, necrosis often is only a phase of the pathologic process, and it is not necessarily present in all cases.

Osteochondroses Juvenil — Dysostoses Enchondral

Summario in Interlingua

Es reportate un caso de morbo de Legg-Calvé-Perthes del articulation coxo-femoral con aspectos que subleva nove problemas etiologic.

Le autor characterisa le hereditari dysostoses enchondral — chondrodystrophias atypic, osteochondrodystrophias, multiple disturbationes del genese epiphysee, etc.—e continua con un discussion del relation inter le plus leve grados de ille dysostoses, i.e. le constitution dysostotic, e le osteochondroses juvenil. In le osteochondroses juvenil, necrose es frequentemente non plus que un phase del processo pathologic, e illo non es necessarimente presente in omne caso individual.

Le occurrentia del disturbation circulatori que characterisa le osteochondroses juvenil depende in multe casos non solmente del effecto de exogene factores mechanic sed etiam del presentia de un primari disturbation hereditari in le disveloppamento del structuras epiphysee. Le importantia relative del factores endogene e del factores exogene varia ab un caso al altere. Il es probabile que un precoce disveloppamento physiologic del centros in question (i.e. del epiphyses vis-a-vis del apophyses) corresponde a un plus forte effecto del factores endogene, sin reguardo al grado e genere del influentia mechanic exogene.

Le componente endogene in le etiologia de multe osteochondroses juvenil es representate per le epiphysee dysostoses enchondral. Le rationes que supporta iste conception estanto genetic como etiam clinic, roentgenologic, e histologic. Illos es discutite in detalio. *Dysostose es le causa principal in casos familial, multiple, bilateral, e relativemente precoce. Illos es frequentemente associate con leve grados de retardo in le maturation skeletic e con un pauco pronunciate nanismo.*

Ab le puncto de vista etiologic, tres gruppos de osteochondroses juvenil es distinguibile:

1. Osteochondroses a base predominantemente endogeno-dysostotic, in que le disveloppamento de un total necrose ossee non es necessari in omne casos.

2. Osteochondroses a base dysostotic-mechanic mixte.

3. Osteochondroses a base predominantemente exogeno-mechanic con presentia obligatori de necrose ossee.

Iste gruppos es confrontate con le minus frequente osteochondroses ab altere causas (per exemplo hormonal, hematopathologic, etc.). Ab le puncto de vista etiologic, le osteochondroses se presenta, per consequente, como resultato de un multiplicitate de factores. Il es ben justificate que le termino syndrome es usate de plus in plus frequentemente etiam in le presentia de un sol localisation. Le recognition del presentia possibile de un componente dysostotic constitutional in osteochondroses juvenil es de signification practic pro le diagnose, pro le prevention de un disveloppamento bilateral del morbo, e pro le evalutation del rolo del morbo in connexion con accidentes.

19

Thawing the Frozen Shoulder

DUNCAN C. MCKEEVER, M.D., F.A.C.S.*

The term *frozen shoulder* is not a scientific one, yet it is so clearly descriptive of the condition to which it is applied that every doctor who has ever seen a case immediately recognizes the symptom complex it designates. Insidiously, after slight injury, during convalescence from an illness, such as a coronary attack, or without any injury or illness, one or both shoulders begin to lose their normal range of motion. Over several weeks or months the limits of motion are restricted progressively. During this time there are severe aching in the shoulder at night, a gradual atrophy of the muscles, particularly of the shoulder, and very acute pain if the range of limited motion imposed by the condition is exceeded forcibly, either actively or passively.

The condition is a serious one for the usually middle-aged patient, who may lose his ability to be employed gainfully, to engage in recreational activity or even to carry on the normal functions of living such as dressing, undressing, bathing and, in general, caring for himself. There is a loss of sleep and rest with resulting nervous tension, aggravated by acute pain on forced or sudden movement. As the range of shoulder motion approaches the point of immobility, the pain may be lessened somewhat, and the patient, having exhausted various ineffectual and often painful methods of treating what has been diagnosed as bursitis or neuritis, becomes resigned to the condition and at least partially accepts his disability, which may persist, or he may slowly recover spontaneously.

For many years this condition has been treated empirically as a purely local condition. Such treatment ranges all the way from complete neglect, through the administration of local heat or diathermy, salicylates or other medications and various local injections, including Hydrocortone, to the forcible manipulation and stretching of the shoulder under anesthesia, followed by wide abduction and strenuous physiotherapy, which only the more rugged individuals are able to tolerate. The latest fad in local treatment is supersonic therapy.

The broader concept that the frozen shoulder is a local manifestation of a general metabolic state can lead one to a much more rational concept of the etiology of the condition and a more rational treatment. If this concept is understood thoroughly and the treatment conceived as a result of it is carried out meticulously, frozen shoulder ceases to be a problem, and its therapy, which formerly required many months, can be completed and the patient restored to full pain-free function within a period ranging from a few days in cases of short duration to from 6 to 8 weeks in the most severe and prolonged cases.

ETIOLOGY AND PATHOGENESIS OF THE CONDITION

The etiologic concept applicable to this condition is equally applicable to all the manifestations of degenerative change in the aging or ill body. The premises set forth are applicable in many other clinical conditions, and the concept is equally useful in the

* Houston, Texas

understanding and the treatment of these other conditions, many of which, like frozen shoulder, have been treated as purely local conditions. Briefly stated, without elaboration, this concept is as follows:

The so-called frozen shoulder is a local manifestation of a general metabolic fault. It is a manifestation of degenerative disease that can exist only in a person who is in a state of negative metabolic balance. Negative metabolic balance implies that the general catabolic processes are going on at a greater rate than the anabolic processes, and, therefore, all tissues subject to functional attrition or degenerative change are not being replaced at the rate at which they are being destroyed. The degree of deficit varies in different individuals and under different conditions of health and stress. If a local manifestation of this metabolic imbalance is to be treated successfully and efficiently, the physiologic state of the patient must be changed from one of catabolism to one of anabolism. If this can be accomplished, frozen shoulder and many related conditions will heal themselves, and all of them will respond much more readily to both conservative and surgical therapy.

Locally, in the shoulder, the condition may be initiated by slight injury, by local ischemia resulting from enforced immobility or by reaction to the friction imposed by an old injury modified by temporary immobility. It may be associated with excessive collagen deposition in the joint. The shoulder is the only joint in the body that remains almost 100 per cent of the time at or near one of its extremes of motion and passes to the other extreme rarely. In some persons it seldom reaches the other extreme, if it does so at all. Local inflammation is followed by exudation, organization and pannus formation identical with that seen in the arthritides, to which it is related. The end-result, if immobility is continued or motion is limited by pain, is a progressive adhesion of the joint and the synovial surfaces within the confines of the capsule of the joint.

The adherence starts at the periphery. During this stage of the development of the condition, forced motion or continued aggravation through excessive use may make the condition advance more rapidly than it otherwise would, due to recurrent disruption of the newly formed adhesions, which then form more strongly than ever during the ensuing period of reflex and protective muscle spasm. Such a joint can be mobilized under local or general anesthesia, but even with care to produce no additional injury, such as fracture or muscle avulsion, it will not retain this mobility unless the patient exercises vigorously and his general state of health can be improved materially. Only a very rugged and stoical individual can tolerate the pain associated with such treatment. If his general state of health can be improved sufficiently, the forcible manipulation under anesthesia becomes entirely unnecessary, and it is probable that in time the condition may heal itself under these conditions. Recovery can be hastened materially by physical therapy administered properly.

The therapy to be applied to the condition known as frozen shoulder should consist, then, of medical treatment to alter the patient's physiology from one of catabolism or negative metabolic balance to one of anabolism or positive metabolic balance, and to apply such local treatment to the shoulder as is necessary to attain a maximum rate of recovery. This rather simple statement has many facets. There can be no halfway measures in carrying out this treatment. It must be meticulous and complete. In some clinics it may be possible to obtain adequate co-operation from internists and rheumatologists to take advantage of their assistance in carrying out the medical portion of the treatment, but if this is not the case it can be carried out by any doctor. The physical therapy portion of the treatment must be supervised carefully and must be in the hands of a thoroughly trained and experienced physical therapist, one who knows what to do with his hands and with

the patient's muscles rather than one who relies entirely on various pieces of high-priced and usually ineffectual apparatus which are expected to conserve the therapist's energy and substitute for his brain.

THE MEDICAL REGIMEN

Basically, the patient in the state of positive metabolic balance is ingesting, absorbing and using properly an adequate balanced supply of proteins, minerals and vitamins, and his endocrine status must be such that anabolic physiology is ensured.

PROTEINS

It should be ascertained that the patient is ingesting an adequate supply of protein, mainly from such sources as meat, milk, eggs and cheese. If necessary, the protein intake may be augmented by protein lysates and concentrates by giving gelatin orally. A minimal protein intake is 100 Gm. per day. Excessive protein intake is to be avoided in the presence of the so-called collagen diseases.

MINERALS

An adequate supply of minerals, including trace minerals, must be ensured. The most important mineral necessity and the most frequent deficiency is in calcium. Adequate intake can be ensured by approximately 2 to 3 glasses of whole milk, buttermilk or skimmed milk per day. If weight gain is to be avoided, skimmed milk and buttermilk are preferable, and the buttermilk contains considerable protein as well as a greater relative amount of mineral. People who for any reason cannot drink milk or have a strong dislike for milk should be given oral calcium in some form and in an adequate amount. It should be given on an empty stomach.

VITAMINS

An adequate vitamin intake is essential to health. An adequate vitamin intake during health may be entirely inadequate during any disease condition, incident to any operation or under any condition of physiologic stress. This is particularly true of B and C vitamins, of riboflavin and niacin. The only way to be sure that the patient is getting an adequate supply of these essentials is to administer them in some form of ultiple vitamin or combined multiple vitamin and mineral capsule, many of which are on the market. It is probable that few, if any, of them contain an adequate amount of ascorbic acid, and usually it is advisable to augment this factor in the vitamin intake by giving from 250 to 500 mg. of extra vitamin C per day.

ABSORPTION

Having ensured an adequate intake of the above essentials, we must do everything we can to ensure their absorption. Achlorhydria and gallbladder disease both seem to cause some interference with calcium absorption and protein assimilation. The presence of a normal level of calcium in the blood is of no significance whatever, as it gives no indication as to which way the calcium is going —whether the patient is losing calcium at too great a rate or is retaining it in adequate amount. A qualitative Sulkowitz test of the urine will give a rough idea of the patient's status in this respect. A patient should have such a test at the beginning of treatment, and if the calcium is being excreted at too great a rate, it should be carried to a negative state by administration of adequate steroid hormones, details of which will be given later. After the Sulkowitz test becomes negative, the calcium and the vitamin D intake should be increased until it again becomes slightly positive while the steroids are continued

Protein Absorption

Many patients who have a more than adequate intake of protein run a consistently low level of blood protein. Every effort should be made to raise this level by giving protein concentrates, oral hydrochloric acid to assist digestion if any achlorhydria is suspected or present, and even the administra-

tion of intravenous protein lysates; or, if the patient is anemic, one, two or more blood transfusions.

Vitamin Absorption

Vitamins presumably are absorbed in adequate amounts if they are ingested in adequate amounts. The only common exception to this is that patients who are taking mineral oil do not absorb vitamins properly because of the affinity of the mineral oil for the vitamins which are carried out of the body with the mineral oil without having a chance to be absorbed. Therefore, all mineral oil cathartics, including emulsions, should be discontinued in patients under this regimen.

UTILIZATION

Given a patient who has an adequate intake of minerals, vitamins and proteins and a normal absorption of these substances, their utilization is dependent on the presence of an adequate supply of steroid hormones, particularly of androgenic and estrogenic hormones and thyroid. In any postmenopausal or posthysterectomy female, or in any male past 50 or 55, and in any individual at any age who shows manifestations of degenerative change (graying hair, Heberden's nodes, thickened skin, brittle nails), these substances can be assumed to be present in inadequate amounts. If normal physiology is to be restored, their administration is imperative. The generally accepted physiologic balance between androgenic and estrogenic hormones is considered to be in the relation of 10 to 20 androgenic units to 1 estrogenic unit, and this ratio is to be used in the administration of these hormones to both males and females. The total administration of androgenic hormones to females should not exceed 300 mg. per month.

From a practical standpoint, if a female begins to get soreness of the breast or begins to have menstrual bleeding, the ratio of androgen to estrogen should be increased. If a man begins to get soreness of the breast, the ratio of androgen to estrogen should be increased. If a female begins to show signs of virilism, such as changes in the voice or excessive growth of hair, the ratio of estrogen to androgen should be increased. If a male shows signs of increased virilism, he probably will not complain. The patient should be warned that these conditions may occur, that they are harmless and that they are temporary. If the patient is not so warned, a female who begins to bleed may rush to a gynecologist who, not realizing that she is taking estrogens, may rush her to the hospital and perform a diagnostic curettement fearing that she has a malignancy. The possibility of withdrawal bleeding in females when this therapy is discontinued, if it is, must also be conveyed to the patient.

At least one company has on the market a capsule containing androgens and estrogens in the above proportions and also containing all the vitamins, except possibly vitamin C, in adequate amount and all the minerals, including trace minerals. The ascorbic acid deficiency in this preparation is to be corrected.

THYROID

Almost every patient past 50 will tolerate the administration of at least 1 grain of thyroid daily. It can be given empirically, or, if the physician is so inclined, it can be administered after radioactive iodine or protein-bound iodine studies of the thyroid state. The presence of heart disease is not a contraindication to its administration.

The more potent steroid hormones may be useful on a temporary basis, and Meticorten or Sterane, 2, 3 or even 4 or more tablets daily for the first week of treatment, often will get the patient started on mobilization of the shoulder with much less discomfort and at a much faster rate. It should be used concurrently with the therapy outlined above and usually can be discontinued after 5 or 10 days. In my opinion, it should be discontinued at that time.

The presence of a gouty diathesis should be explored in every case. The presence of

bursal deposits makes the gout diagnosis more probable. Neither the gout nor the nongouty deposits alter the treatment, except that if gout is present, Probenecid in adequate amounts should be added to the treatment. If the treatment outlined is carried out, operation on the deposit rarely is necessary.

The above brief résumé is not intended to be a scientific explanation of all the problems involved. It contains many dogmatic statements. It is merely an attempt to bring together a body of information applicable to a specific condition in such a manner that the rationale of its use in this condition may be understood by the physician and readily explained to the patient, so as to ensure his complete co-operation and his persistence in treatment until maximum benefit is secured and to encourage his continuance of part of the treatment on a prophylactic basis.

Physical Therapy

The role of the physical therapist in the treatment of frozen shoulder is of paramount importance, and attention to the details of his ministration is essential. In this field, as in the medical aspect of the condition being treated, attention must be given to the patient's general physiology as well as to the local condition. The general muscle tone must be improved by postural type exercises. Normal posture must be restored insofar as this is possible. Head carriage and muscle balance in the neck should be given particular attention, as this muscle balance always is disturbed. There are spasm and weakness of the anterior muscles and extreme fatigue of the posterior muscles in the neck. The following are considered to be the minimal exercises in this and other conditions:

1. **Position.** Lie on the back with the knees bent up so that the feet are approximately 18 inches from the buttocks. *Action.* Raise the head so that the chin is on the chest, then raise the shoulders slowly as far as possible, sitting up if able.

2. **Position.** Lie on one side. *Action.* Raise the head so that the ear goes directly toward the shoulder without rotation of the neck. Repeat on the other side.

3. **Position.** Lie prone, face to one side. *Action.* Bring the shoulder blades together, tighten the abdominal muscles so as to fix the pelvis and prevent overextension of the lumbar spine, raise head and shoulders, turn the head to the opposite side, lower the head, relax.

These general exercises should be carried out at least twice daily, starting with 10 times on each exercise and gradually increasing to 25 times on each exercise. They should be continued for at least 2 months. Following this, they should be done at least once daily for 2 months or longer.

Physiotherapy applied directly to the shoulder should consist of assisted and unassisted voluntary abduction, adduction and rotation movements. A minimal amount of completely passive forcing should be carried out. The patient may measure his progress by keeping a record of how high he can reach on the wall, but the greatest amount of attention should be directed toward muscular development. For the rotators of the shoulder and in the deltoid, the biceps and the triceps a 10-lb. sash weight offers excellent resistance for accomplishing this A small bucket of sand on the end of a rope, which is run over a pulley in the ceiling and used to assist in raising the arm, is helpful. A wheel placed on the wall, so that the patient may grasp the spokes or a handle on the rim and rotate the wheel, may be utilized as treatment progresses The patient is given arm-swinging and abduction exercises and rotation exercises to carry out at home several times daily. The physiotherapist should treat the patient not oftener than three times, probably only twice, a week. Violent manipulation which would excite reflex muscle spasm is to be avoided at all costs. If manipulation is carried out, it should be confined to assistance of voluntary motions and should not involve passive motion against patient resistance.

If this regimen is adhered to carefully, a patient with moderate restriction of motion and a duration of symptoms of from 1 to 3 months can usually be restored to a full range of pain-free motion within 10 days to 3 weeks. The most prolonged and resistant cases can be restored to a normal range of pain-free motion in approximately 3 months, and they will have been 80 per cent to 90 per cent relieved within 3 to 6 weeks. It is the author's opinion that treatment should be continued until a full range of motion is restored. In the last 5 years, using the treatment outlined above, the author has treated successfully 56 cases of so-called frozen shoulder, and no operation has been necessary. It is conceivable that operation may be necessary in a case in which very dense adhesions have formed in the bicipital groove. If a patient continues to have symptoms localized in this area after having been restored to positive metabolic balance and having had an adequate course of physiotherapy, the author would not hesitate to operate and transplant the long head of the biceps to the coracoid. This operation also might be justifiable if the condition had a tendency to recur. However, if the patient is maintained in a condition of positive metabolic balance, recurrence is not to be anticipated, and the author feels that operative interference rarely would be necessary.

Disgelar le Spatula Congelate

Summario in Interlingua

Le termino *spatula congelate* non es scientific, sed illo es clarmente descriptive. Le condition assi designate se disveloppa lentemente post leve formas de trauma, durante le reconvalescentia ab morbos como attacco coronari, o etiam sin morbo e sin trauma. Illo pote esser unilateral o bilateral. Le patientes es usualmente de etate medie. Le impedimento resultante pote esser si serie que le patiente perde su capacitate de exercer un empleo remunerative o mesmo de exercer le functiones normal del vita quotidian, como vestir se, disvestir se, etc. Le prime symptoma es dolor nocturne. Lentemente le mobilitate del spatula es restringite. Quando illo approacha un stato de immobilitate complete, il occurre que le grado del dolor recede un pauco. Alora le patiente—qui ha exhaurite varie inefficace e dolorose methodos de tractamento—se resigna e accepta su stato de invaliditate que pote persister sed que etiam pote subsider lente- e spontaneemente.

Durante multe annos on ha tractate le spatula congelate como un condition local. Le formas de tractamento essayate include le extremos de neglection complete e del administration de calor, medicationes, injectiones, manipulation forciate, e therapia supersonic.

Le minus restringite concepto que le spatula congelate es un manifestation local de un stato metabolic general pote ducer nos a un conception plus rational del etiologia e ergo del therapia. Le entitate clinic que es communmente designate como spatula congelate cessa alora esser un problema, e su tractamento es simplificate e accelerate.

Le condition es un manifestation de alterationes, e le mesme tractamento es applicabile o morbide. Il existe altere tal manifestationes, e le mesmo tractamento es applicabile al majoritate de illos. Le condition pote occurrer solmente in subjectos qui se trova in un stato de balancia metabolic negative, i.e. in subjectos in qui le processos catabolic o destructive procede plus rapidemente que le processos anabolic o reconstructive. Le objectivo del tractamento debe esser le reversion de iste stato physiologic.

Le spatula es le sol articulation del corpore que remane quasi permanentemente in

o proxime a un del positiones extreme de su mobilitate. In le evolution del spatula congelate, inflammation local es sequite per exsudation, organisation, e formation de panno identic a lo que es observate in le arthritides (con que illo es apparentate). Il occurre un adhesion progressive del articulation e del superficies synovial intra le confinios del capsula. *Si le spatula es mobilisate per* fortia, le condition deveni pejor a minus que le stato de sanitate general del patiente es meliorate, e si le stato de sanitate general es meliorate, le mobilisation forciate del articulation deveni superflue. Le restablimento pote esser accelerate per le administration de formas appropriate de physiotherapia.

Le therapia deberea consister de un regime medical destinate a alterar le physiologia del patiente ab su stato de catabolismo o de balancia metabolic negative a un stato de catabolismo o de balancia metabolic positive e del application al spatula del tractamento requirite pro effectuar le plus rapide restablimento possibile. Nulle mesuras indecise es tolerabile in le execution de iste tractamento. Le physiotherapia debe esser in le manos de un cautemente controlate e ben trainate e experientiate physiotherapeuta, i.e. un homine qui sape usar su manos e cognosce le potentialitates del musculos del patiente in loco de fider se completemente a varie pecias de costose e usualmente inefficace appartura destinate a sparniar le energia del therapeuta e a reimplaciar su cerebro.

Le Regime Medical

In principio, un patiente se trova in stato de balancia metabolic positive si ille ingere, absorbe, e utilisa commensuratemente un adequate e balanciate provision de proteinas, minerales, e vitaminas e si, in plus, su stato endocrin es capace a assecurar un physiologia anabolic. In patientes con spatula congelate, le ingestion de proteina, minerales, e vitaminas debe esser supplementate. Le absorption de iste substantias *debe esser assecurate. Isto non es possibile* in caso de carentia de un del enzymas digestive. Le absorption de calcium non functiona in le absentia de libere acido chlorhydric in le stomacho o in patientes con morbo del vesica biliari. Si o non le nivello sanguinee de calcium es normal non importa, proque illo non reflecte le balancia de calcium. Le qualitative test de Sulkowitz in *le urina forni un idea general del stato del* patiente in iste respecto. Transfusiones de sanguine e proteinas supplementari es a vices necessari. Le absorption de vitaminas non debe esser obstruite per le ingestion de catharticos de oleo mineral.

Solmente patientes qui ha un adequate e balanciate provision de hormones steroide es capace a ben utilisar le ingerite minerales, vitaminas, e proteinas in le reconstruction del usate e ledite tessuto. Secundo le generalmente acceptate vista, le balancia physiologic inter le hormones androgenic e estrogenic require *10 a 20 unitates androgenic* pro 1 unitate estrogenic. Iste proportion monstra variationes in certe individuos, sed in general illo es applicabile a masculos e a femininas. Le administration total de hormones androgenic a femininas non deberea exceder 300 mg per mense. Le symptomas de dosages excessive de estrogenos es sensibilitate del pectores in homines e in faminas e sanguination menstrual in feminas. Le symptomas de virilismo o doses excessive de androgenos es mutationes del voce o crescentia excessive de ca pillos con eruptiones in le facies de feminas. *Homines con symp*tomas de virilismo augmentate non se plange. Le patientes debe esser informate que iste conditiones pote occurrer, que illos es innocue e temporari. Alteremente, un femina qui comencia haber sanguination menstrual pote opinar que illa suffre del disveloppamento de un tumor maligne, e iste opinion pote etiam esser le conclusion de su medico o gynecologo. Non requirite hospitalisation con intervention chirurgic pote esser le resultato. Le possibilitate de sanguination de disaccostumation al fin del therapia in feminas debe etiam esser explicate al patiente.

Quasi omne patiente de plus que 50 annos de etate tolera le administration de al minus 1 g de thyroide per die. Illo pote esser administrate empiricamente o post le execution del appropriate tests. Morbo cardiac non es un indication contra su uso.

Le plus potente hormones steroide es utile in certe casos, quando usate temporarimente pro lancear le patiente in le cammino del restablimento con un minimo de disconforto. Illos non deberea esser continuate in ultra de cinque a dece dies.

Le possibilitate de diathese guttose deberea esser investigate in omne caso. Si gutta es diagnosticate, le tractamento non es cambiate, excepte que probenecido in quantitates adequate es addite. Interventiones chirurgic a causa de depositos spatular es rarmente necessari.

Iste breve summario non pretende a esser un explication scientific de omne le problemas implicate. Illo contine numerose formulationes dogmatic. Su function es colliger un fundo de informationes applicabile a un condition specific e isto in un forma que le principios del uso de ille informationes in le condition in question pote esser comprendite per le medico, pote esser facilemente explicate al patiente, e es utilisabile con bon prospectos de successo. On debe incoragiar le patiente a continuar un parte del tractamento como mesura prophylactic.

Le tono muscular general e le balancia postural del musculos debe esser meliorate per exercitios. Melioration del portation del capite e del balancia muscular in le collo va resultar in consequentia. Le condition spatular es frequentemente complicate per affectiones secundari in le area mentionate. Le sequente exercitios es considerate como minimal sed adequate:

1. **Position.** Jacer super le dorso, le genus flectite de maniera que le pedes dista circa 45 cm ab le gluteos. *Action.* Levar le capite usque le mento tocca le thorace; postea levar le spatulas lentemente, si possibile usque al position sedente.

2. **Position.** Jacer super un latere. *Action.* Levar le capite con le aure orientate directemente verso le spatula sin rotation del collo. Repeter al altere latere.

3. **Position.** Decubito ventral, facie al latere. *Action.* Facer approchar le scapulas. Tensionar le musculos abdominal de maniera a fixar le pelve e prevenir hyperextension del lumbar columna vertebral. Levar le capite e le spatulas. Tornar le capite al altere latere. Abassar le capite. Relaxar.

Iste exercitios general deberea esser executate al minus duo vices per die, omne exercitio repetite 10 vices al initio e augmentate usque a 25 vices. Continuar al minus duo menses. Postea un vice per die durante duo menses additional.

Le physiotherapia applicate directemente al spatula deberea consister de assistite abduction, adduction, e rotation voluntari. Grados minimal de completemente passive fortiation es permissibile. Le patiente pote mesurar su progresso per registrar le altor a un muro que ille pote attinger con su mano. Un polea con contrapeso (per exemplo un situla con arena) pote esser usate pro assister le elevation del bracio. Un rota a exercitios spatular—montate al muro de maniera que le patiente pote sasir le radios o un manico al circumferentia del rota pro tornar lo—es etiam utilisabile. Le physiotherapeuta deberea tractar le patiente non plus que duo vices per septimana. Formas violente de manipulation que excitarea spasmos de musculos reflexe debe esser evitate a omne costo.

Si iste regime es observate, un patiente con moderate restriction de mobilitate e un duration del symptomas de un a tres menses pote esser restaurate al complete e nondolorose amplitude de motion intra dece dies a tres septimanas. Le plus prolongate e resistente casos pote esser restaurate al normal amplitude de nondolorose motion in circa tres menses. In tal casos, un alleviamento de 80 a 90 pro cento es attingite intra tres a sex septimanas. Le tractamento debe esser continuate usque le complete amplitude de motion es restaurate.

In le curso del passate cinque annos, le

autor ha usate le supra-describite regime con bon successo in le tractamento de 56 casos del si-appellate spatula congelate, sin intervention chirurgic e sin manipulation sub anesthesia. Il non es impossibile que un operation deveni necessari in un caso in que un adhesion multo dense se ha formate in le sulco bicipite. Alora le capite longe del bicipite debe esser transplantate al processo coracoide.

20

High Femoral Neck Fractures Treated by Multiple-Nail Fixation

A Survey of 100 Cases

JAMES T. GREEN, M.D., AND FRANCIS H. GAY, M.D.*

The problem of the fractured hip, which usually occurs in the aged, still confronts the surgeon. Nonunion and avascular necrosis continue to baffle him. Most of the reporting surgeons used the flanged nail; relatively few reports were made on multiple-nail fixation. This survey of a group of patients on whom the multiple-nail method was used for fixation will help to establish that problems common to the fracture of the high femoral neck are the same, regardless of the type of fixation employed at present.

During the past 10½ years we have nailed 243 fractured hips, 100 of which have been high femoral neck fractures. Fixation in this group of 100 has been accomplished by using 4 or more adjustable stainless-steel nails of the Austin Moore type (Fig. 1). In 1940, one of us (J. T. G.) was co-author of a paper reporting 50 femoral neck fractures treated by multiple nails, in 90 per cent of which there was primary bone healing and in 10 per cent aseptic necrosis of the head The present series does not show such fine results.

We propose to present the results of treatment by multiple nails in a series of 100 high femoral neck fractures, to discuss the necessity of secondary operations and the occurrence of avascular changes in the femoral head following bone healing (Fig. 2), and to state our ideas on changing the operative procedure in an attempt to obtain more rigid fixation and more rapid union.

* Columbia, S. C.

METHOD OF TREATMENT

The conservative treatment of all high femoral neck fractures, both impacted and displaced, is that of early nailing. If in satisfactory position, the impacted fractures are nailed as such. If unsatisfactory, attempts are made to roll the head into better position without displacing the fragments. In the displaced fractures, manipulation is carried out by several different maneuvers. In some, traction and internal rotation are sufficient for reduction; in others, traction is applied to the flexed hip in external rotation and followed by internal rotation and extension. Traction has been applied in adduction followed by internal rotation and abduction. It has been difficult to obtain perfect reduction, and the result has been regarded as satisfactory when the fragments were only 1 or 2 mm. off. On 4 occasions, satisfactory closed reduction was impossible; open reduction was necessary; and even on opening the fracture there was difficulty in getting perfect position.

After what appears to be satisfactory clinical reduction, a roentgenogram in the anteroposterior view is taken. Two small



Fig. 1. White female, aged 65. (*Left*) Displaced high femoral neck fracture. (*Right*) Same fracture 2½ years after nailing with multiple nails. Hip is asymptomatic, and *there is essentially full function.*

holes are drilled with a reamer in the lateral cortex of the femur inmmediately below the greater trochanter. Two nails are inserted, followed by a roentgenogram in the antero-posterior and lateral frog position. At times x-ray facilities have not functioned properly, then tension mounts and frustration is not unknown. Use of the polaroid technic has reduced the operating time considerably and lessened the tension. If the first 2 nails are satisfactory, additional nails are inserted in an effort to effect a parallelogram with nails fixing the fracture in a manner of reinforcing concrete, the nails being placed as far as possible toward the periphery of the neck. The nails are inserted by hand chuck and are felt to engage the head firmly. If not, they are redirected, even at the loss of the



Fig. 2 White female, aged 70. (*Top, left*) Displaced high femoral neck fracture. (*Top, right*) Six months following nailing, one nail protruding into acetabulum. (*Bottom, left*) Nineteen months following fracture. Nails have been changed. (*Bottom, right*) Six years following fracture. Nails have been removed. There are no symptoms in regard to hip. There is slight limitation of hip motion.

attempted parallelogram. It is difficult to obtain the parallelogram because of the frequency with which a nail may strike the cortex and be deflected. Light impaction is carried out, the nuts of the nail being driven firmly against the cortex. The excess of the nail is cut off. The threads are crimped distal to the nut of the nail, and the ends of the nails are bound together with a loop of stainless-steel wire. No gadget or mechanical aid is used, a freehand effort has been made to get the parallelogram of nails in as nearly vertical a position as possible. Stainless-steel nails, 7/64 inch in diameter, were used at first, but later 1/8-inch nails were preferred.

Of this group treated by us, 83 per cent were private patients. Racial difference was rather marked, 88 per cent being white. This may be of some significance in an area in which the normal Negro population is 39 per cent. Sixty-two per cent of the fractures were in the left hip. The average age of the group was 68 years. Seventy-two per cent were females. There were 7 fractures due to violent trauma and 93 due to simple falls. On several occasions, particularly in the older group, patients volunteered that they broke their hip and then fell. Most of the patients were admitted to the hospital on day of injury. Hip nailing was carried out as soon as practicable: 7 per cent were operated upon on the day of fracture; 44 per cent, the day after; 35 per cent, the second day after injury; 10 per cent, between the third and the 20th days; and 4 per cent, more than 20 days later.

There were many preoperative complicating diseases. In addition to the usual cardiovascular changes of the aged, 12 per cent had multiple fractures, 9 per cent had psychosis, 8 per cent were hemiplegics and 6 per cent were diabetics.

The operation was done under spinal anesthesia in 95 per cent of the cases, effort being made to obtain one-legged anesthesia. Blood transfusions were given in the operating room in 65 per cent without untoward reaction. There were 4 deaths in the hospital within 26 days. There were 2 serious postoperative wound infections, one in a diabetic and the other in a senile psychotic, both of whom died within 2 months. One patient had phlebothrombosis with pulmonary embolism and survived.

Following the operation attempts were made to get the patient out of bed as quickly as possible. Seventy-seven per cent were ambulatory in the first week after operation. Crutch walking was allowed only by those thought to be capable of it, and only 47 per cent were allowed this activity during the healing of the fracture.

TABLE 1. IMPACTED FRACTURES

Impacted fractures	23
Death	1
Lost to follow-up	2
Bone healing	20
Avascular necrosis	3 (15%)

RESULTS

Impacted Fractures. The impacted fractures (Table 1) do not present a serious problem in fracture healing in later complications. There were 23 impacted fractures: 15 were nailed as they were; 1 died of a coronary thrombosis on the 14th day following nailing; 2 were lost to follow-up; and the remaining 12 proceeded to bony union in an average of 6.3 months. Eight impacted fractures were manipulated, and all proceded to solid union in an average of 6 months. Of the 20 impacted fractures followed, all became solid. Three later developed avascular necrosis, 1 in the manipulated group and 2 in the nonmanipulated group. Only 1 of these avascular necroses became symptomatic.

Displaced Fractures. This group (Table 2) gave the greatest difficulty in the treatment of high femoral neck fractures. There were 77 displaced fractures. Satisfactory reduction was obtained in all but 4 cases. These 4 cases were openly reduced, 2 proceeded to union and 2 to nonunion. Three patients died in the hospital within 26 days,



FIG. 1. White female, aged 65. (*Left*) Displaced high femoral neck fracture. (*Right*) Same fracture 2½ years after nailing with multiple nails. Hip is asymptomatic, and there is essentially full function.

holes are drilled with a reamer in the lateral cortex of the femur immediately below the greater trochanter. Two nails are inserted, followed by a roentgenogram in the antero-posterior and lateral frog position. At times x-ray facilities have not functioned properly, then tension mounts and frustration is not unknown. Use of the polaroid technic has reduced the operating time considerably and lessened the tension. If the first 2 nails are satisfactory, additional nails are inserted in an effort to effect a parallelogram with nails fixing the fracture in a manner of reinforcing concrete, the nails being placed as far as possible toward the periphery of the neck. The nails are inserted by hand chuck and are felt to engage the head firmly. If not, they are redirected, even at the loss of the



FIG. 2 White female, aged 70. (*Top, left*) Displaced high femoral neck fracture. (*Top, right*) Six months following nailing, one nail protruding into acetabulum. (*Bottom, left*) Nineteen months following fracture. Nails have been changed (*Bottom, right*) Six years following fracture. Nails have been removed. There are no symptoms in regard to hip. There is slight limitation of hip motion.

attempted parallelogram. It is difficult to obtain the parallelogram because of the frequency with which a nail may strike the cortex and be deflected. Light impaction is carried out, the nuts of the nail being driven firmly against the cortex. The excess of the nail is cut off. The threads are crimped distal to the nut of the nail, and the ends of the nails are bound together with a loop of stainless-steel wire. No gadget or mechanical aid is used, a freehand effort has been made to get the parallelogram of nails in as nearly vertical a position as possible. Stainless-steel nails, 7/64 inch in diameter, were used at first, but later 1/8-inch nails were preferred.

Of this group treated by us, 83 per cent were private patients. Racial difference was rather marked, 88 per cent being white. This may be of some significance in an area in which the normal Negro population is 39 per cent. Sixty-two per cent of the fractures were in the left hip. The average age of the group was 68 years. Seventy-two per cent were females. There were 7 fractures due to violent trauma and 93 due to simple falls. On several occasions, particularly in the older group, patients volunteered that they broke their hip and then fell. Most of the patients were admitted to the hospital on day of injury. Hip nailing was carried out as soon as practicable: 7 per cent were operated upon on the day of fracture; 44 per cent, the day after; 35 per cent, the second day after injury; 10 per cent, between the third and the 20th days; and 4 per cent, more than 20 days later.

There were many preoperative complicating diseases. In addition to the usual cardiovascular changes of the aged, 12 per cent had multiple fractures, 9 per cent had psychosis, 8 per cent were hemiplegics and 6 per cent were diabetics.

The operation was done under spinal anesthesia in 95 per cent of the cases, effort being made to obtain one-legged anesthesia. Blood transfusions were given in the operating room in 65 per cent without untoward

TABLE 1. IMPACTED FRACTURES

Impacted fractures	23
Death	1
Lost to follow-up	2
Bone healing	20
Avascular necrosis	3 (15%)

reaction. There were 4 deaths in the hospital within 26 days. There were 2 serious postoperative wound infections, one in a diabetic and the other in a senile psychotic, both of whom died within 2 months. One patient had phlebothrombosis with pulmonary embolism and survived.

Following the operation attempts were made to get the patient out of bed as quickly as possible. Seventy-seven per cent were ambulatory in the first week after operation. Crutch walking was allowed only by those thought to be capable of it, and only 47 per cent were allowed this activity during the healing of the fracture.

RESULTS

Impacted Fractures. The impacted fractures (Table 1) do not present a serious problem in fracture healing in later complications. There were 23 impacted fractures: 15 were nailed as they were; 1 died of a coronary thrombosis on the 14th day following nailing; 2 were lost to follow-up; and the remaining 12 proceeded to bony union in an average of 6.3 months. Eight impacted fractures were manipulated, and all proceeded to solid union in an average of 6 months. Of the 20 impacted fractures followed, all became solid. Three later developed avascular necrosis, 1 in the manipulated group and 2 in the nonmanipulated group. Only 1 of these avascular necroses became symptomatic.

Displaced Fractures. This group (Table 2) gave the greatest difficulty in the treatment of high femoral neck fractures. There were 77 displaced fractures. Satisfactory reduction was obtained in all but 4 cases. These 4 cases were openly reduced, 2 proceeded to union and 2 to nonunion. Three patients died in the hospital within 26 days,



FIG. 1. White female, aged 65. (*Left*) Displaced high femoral neck fracture. (*Right*) Same fracture 2½ years after nailing with multiple nails. Hip is asymptomatic, and there is essentially full function.

holes are drilled with a reamer in the lateral cortex of the femur inmmediately below the greater trochanter. Two nails are inserted, followed by a roentgenogram in the antero-posterior and lateral frog position. At times x-ray facilities have not functioned properly, then tension mounts and frustration is not unknown. Use of the polaroid technic has reduced the operating time considerably and lessened the tension. If the first 2 nails are satisfactory, additional nails are inserted in an effort to effect a parallelogram with nails fixing the fracture in a manner of reinforcing concrete, the nails being placed as far as possible toward the periphery of the neck. The nails are inserted by hand chuck and are felt to engage the head firmly. If not, they are redirected, even at the loss of the



FIG. 2. White female, aged 70. (*Top, left*) Displaced high femoral neck fracture. (*Top, right*) Six months following nailing, one nail protruding into acetabulum. (*Bottom, left*) Nineteen months following fracture Nails have been changed (*Bottom, right*) Six years following fracture Nails have been removed. There are no symptoms in regard to hip. There is slight limitation of hip motion.

attempted parallelogram. It is difficult to obtain the parallelogram because of the frequency with which a nail may strike the cortex and be deflected. Light impaction is carried out, the nuts of the nail being driven firmly against the cortex. The excess of the nail is cut off. The threads are crimped distal to the nut of the nail, and the ends of the nails are bound together with a loop of stainless-steel wire. No gadget or mechanical aid is used, a freehand effort has been made to get the parallelogram of nails in as nearly vertical a position as possible. Stainless-steel nails, 7/64 inch in diameter, were used at first, but later 1/8-inch nails were preferred.

Of this group treated by us, 83 per cent were private patients. Racial difference was rather marked, 88 per cent being white. This may be of some significance in an area in which the normal Negro population is 39 per cent. Sixty-two per cent of the fractures were in the left hip. The average age of the group was 68 years. Seventy-two per cent were females. There were 7 fractures due to violent trauma and 93 due to simple falls. On several occasions, particularly in the older group, patients volunteered that they broke their hip and then fell. Most of the patients were admitted to the hospital on day of injury. Hip nailing was carried out as soon as practicable: 7 per cent were operated upon on the day of fracture; 44 per cent, the day after; 35 per cent, the second day after injury; 10 per cent, between the third and the 20th days; and 4 per cent, more than 20 days later.

There were many preoperative complicating diseases. In addition to the usual cardiovascular changes of the aged, 12 per cent had multiple fractures, 9 per cent had psychosis, 8 per cent were hemiplegics and 6 per cent were diabetics.

The operation was done under spinal anesthesia in 95 per cent of the cases, effort being made to obtain one-legged anesthesia. Blood transfusions were given in the operating room in 65 per cent without untoward reaction. There were 4 deaths in the hospital within 26 days. There were 2 serious postoperative wound infections, one in a diabetic and the other in a senile psychotic, both of whom died within 2 months. One patient had phlebothrombosis with pulmonary embolism and survived.

TABLE 1. IMPACTED FRACTURES

Impacted fractures	23
Death	1
Lost to follow-up	2
Bone healing	20
Avascular necrosis	3 (15%)

Following the operation attempts were made to get the patient out of bed as quickly as possible. Seventy-seven per cent were ambulatory in the first week after operation. Crutch walking was allowed only by those thought to be capable of it, and only 47 per cent were allowed this activity during the healing of the fracture.

RESULTS

Impacted Fractures. The impacted fractures (Table 1) do not present a serious problem in fracture healing in later complications. There were 23 impacted fractures: 15 were nailed as they were; 1 died of a coronary thrombosis on the 14th day following nailing; 2 were lost to follow-up; and the remaining 12 proceeded to bony union in an average of 6.3 months. Eight impacted fractures were manipulated, and all proceeded to solid union in an average of 6 months. Of the 20 impacted fractures followed, all became solid. Three later developed avascular necrosis, 1 in the manipulated group and 2 in the nonmanipulated group. Only 1 of these avascular necroses became symptomatic.

Displaced Fractures. This group (Table 2) gave the greatest difficulty in the treatment of high femoral neck fractures. There were 77 displaced fractures. Satisfactory reduction was obtained in all but 4 cases. These 4 cases were openly reduced, 2 proceeded to union and 2 to nonunion. Three patients died in the hospital within 26 days,



FIG. 3. White female, aged 69. (*Top, left*) Displaced high femoral neck fracture nailed with Smith-Petersen nail, at which time the head rolled. Hip remanipulated, and multiple nails were inserted 6 weeks following the original nailing. Head remained angulated. Above roentgenograms made 5 months after nailing with multiple nails. (*Top, right*) Fibular graft inserted. (*Bottom*) Roentgenogram made 8 years following fracture and 7½ years after fibular graft. Excellent hip function.

TABLE 2 DISPLACED FRACTURES

Displaced fractures	77
Deaths	10
Lost to follow-up	6
Invalidism before and after operation	3
Too recent to evaluate	1
Bone healing	38 (66.6%)
Nonunion	19 (33.3%)

4 died within 4 months at home, and 3 died between 4 and 12 months. Three patients were bedridden at the time of fracture, remained so postoperatively, and the x-ray follow-up was inadequate. Six were lost to follow-up, and 1 is too recent to evaluate. This leaves 57 cases which have been followed. Of these, 38, or 66.6 per cent, became solid by roentgenogram in an average of 8.6 months. Minimum healing time was 6 months, and maximum healing was 12 months. Of the group which became solid, 50 per cent had absorption of the neck during the healing period, and 53 per cent had movement of the nails so that the nail either backed out or penetrated through the head. Nineteen, or 33.3 per cent, proceeded to nonunion. All these cases had absorption of the neck, and in only 1 did fixation remain in its original position.

SECONDARY OPERATIONS (Table 3)

It is our policy to watch the progress of healing by x-ray at intervals of 6 weeks, and all patients are encouraged to return to the office for this examination. If there is a change in the position of the head or the nails, the patient is advised to have a secondary operation to adjust the nails in order to improve fixation. In the group of displaced fractures, 19 secondary procedures

TABLE 3. SECONDARY PROCEDURES FOR NONUNION

Fibular graft	8
Iliac graft	2
Subtrochanteric geometric osteotomy	3
Prosthesis	3



FIGS. 4 and 5. Negro, aged 35, with displaced high femoral neck fracture. Fig. 4 (*Above*). (*Left*) Two months and (*right*) 5 months after fracture. The nails have backed out, there is shortening and nonunion.

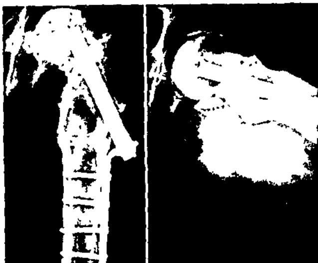


FIG. 5. Subtrochanteric geometric osteotomy performed 6 months after fracture. Healing complete 8 months after osteotomy.

were done to adjust nails. In the impacted fractures, 1 nail adjustment was necessary after the patient had fallen, further impacting the fracture and driving 1 nail into the acetabulum. Nails were removed in 11 cases, all of which were in the displaced fracture group.

During the early years of this series, fibular grafts (Fig. 3) through the neck into the head were used in an attempt to salvage those which appeared to be developing nonunion. Eight such fibular grafts were done, 5 of which proceeded to union in an average of 10½ months. Two appeared to be solid in 5 and 8 months but later dissolved and resulted in nonunion. One died before an end-result was obtained. Two iliac grafts placed in a window in the neck resulted in union in an average of 12 months.

Subtrochanteric geometric osteotomy (Figs. 4 & 5) was done in 3 cases, two of which proceeded to union in an average of 6½ months with excellent functional results. One is too recent to evaluate.

Prosthetic femoral heads of the stem type were used in 3 cases with only fair results.

TWO- TO NINE-YEAR FOLLOW-UP

Sixty-five cases have been studied from 2 to 9 years. Including those which have had secondary operations for nonunion, 55 cases have proceeded to bone healing and 10 have resulted in nonunion. This represents after salvage procedures 84.6 per cent union. Considering only those with displaced fractures, the long-term follow-up represents 79 per cent union.

AVASCULAR NECROSIS

Avascular necrosis (Table 4) occurred usually between the first and the second years after fracture, although it has been observed after 2 years. *The clinical picture* of avascular necrosis varies from no disability to marked disability. The x-ray findings vary from marked irregularity and sequestration of portions of the head to increased density and vacuolization in a normal shaped head. Thirty-four per cent of those with united fractures followed from 2 to 9 years had avascular necrosis. In the

TABLE 4. AVASCULAR NECROSIS

2 to 9 years healed fractures	55 cases
Avascular necrosis	19 cases—(34.5%)
Impacted fractures	3 of 17 cases—(17%)
Displaced fractures	16 of 38 cases—(42%)
Symptomatic	11 of 19 cases—(58%)



FIG. 6. White female, aged 71. (*Left*) Showing healed displaced high femoral neck fracture 20 months after nailing. (Healing complete at 8 months.) (*Right*) Four years after nailing, showing avascular necrosis of the head. Hip is painful and motion limited.



FIGS. 7 and 8. White female, aged 65. Impacted fracture of the neck of the femur. Fig. 7 (*Above*). (*Left*) Six months after fracture and (*right*) 19 months after fracture.



FIG 9. The authors' present method of nailing high femoral neck fractures.



FIG. 8 (*Left*) Four years and (*right*) 5 years after fracture showing avascular necrosis. Hip is painful and motion limited.

displaced fracture group, 42 per cent of those which became solid and were followed for a period of 2 to 9 years had avascular necrosis (Fig. 6). In the impacted fractures (Figs. 7 & 8), there were only 17 per cent with avascular necrosis. Fifty-eight per cent of those with avascular changes had symptoms, the remainder were symptom free at time of the latest examination.

DISCUSSION

The multiple-nail fixation of high femoral neck fractures was thought to be superior to the single-nail fixation because it was an easier technical procedure, it was a better mechanical fixation, it caused less disturb-

ance to the vascular supply to the head, and adjustment of fixation was relatively easy without disturbing the fracture site. However, the results after careful study do not warrant any claim of superiority for this type of fixation. It is now felt that this type of fixation is not sufficiently rigid to overcome fractional irritation at the fracture site and allow bony healing to proceed in an orderly manner. The nails, when placed in the osteoporotic hip, have insufficient fixation in the cortex and insufficient fixation in the area of Ward's triangle, so that minimal motion at the fracture site is possible. Work is being done to add shaft fixation to the multiple nails, but at this time it appears to be too cumbersome to be practical. The shaft fixation attached to the Smith-Petersen nail appears to be more practical and is being used by our group at the present time (Fig. 9).

It has been necessary to watch the fracture healing very carefully. Those who returned for checkup at regular intervals fared much better. Frequently secondary operations were refused by those who were asymptomatic in spite of early changes that were taking place. As a result, salvage operations were not done as soon as they should have been.

Subtrochanteric geometric osteotomy appears to be an excellent procedure during the early phase when union is not progressing normally. In addition to the 3 cases done in this series, 5 others referred for nonunion have been treated by this method with excellent results.

The use of the prosthesis appears to be indicated when nothing else is available. In addition to the 3 prostheses used in this series, 17 other femoral neck fractures have been treated by prosthesis—7 for acute fractures in the aged and 10 for nonunion or aseptic necrosis. Most of these with prostheses have developed what is assumed to be a painful synovitis. The results have been disappointing and, in our experience, the prosthesis is a poor substitute for a normal femoral head.

CONCLUSIONS

1. The multiple-nail fixation for displaced high femoral neck fractures appears to be inadequate to maintain reduction and rigid fixation for early union.
2. The impacted femoral neck fracture when nailed presents relatively little problem in healing or in later complications.
3. The displaced high femoral neck fracture results in a high percentage of nonunion.
4. The long-term follow-up in healed displaced femoral neck fractures shows a higher incidence of avascular necrosis than we had suspected.
5. Salvage procedures frequently are necessary to preserve a functional head of the femur and should be carried out as soon as there is evidence that healing is not progressing satisfactorily.
6. Hip fractures appear to occur less frequently in Negroes than in whites.
7. The prosthetic replacement is a poor substitute for a normal femoral head.
8. Present opinion is that shaft fixation is a necessary addition to the usual neck fixation in high femoral neck fractures.

BIBLIOGRAPHY

Cleveland, Mather, and Fielding, J. W.: A continuing end result study of intracapsular fractures of the neck of the femur, J. Bone & Joint Surg. 36A:1020-1030, 1954.

Dickson, A.: The unsolved fracture, J. Bone & Joint Surg. 35A:805-822, 1953.

Easton, G. O.: Internal fixation in displaced intracapsular fractures of the femoral neck, J. Bone & Joint Surg. 38A:23-32, 1956.

Moore, A. T., and Green, J. T.: Fractures of neck of femur treated by internal fixation with adjustable nails; end result studies, South. Surgeon 9:684-689, 1940.

Fracturas Alto-Transcervical del Femore, Tractate per Fixation a Clavos Multiple

Summario in Interlingua

Es presentate un revista de 100 casos de fracturas alto-transcervical del femore le quales esseva tractate per fixation a clavos multiple. In le casos de fracturas non-displaciate, re-adhesion ossee non representava un problema, ben que necrose avascular occurreva in un micre procentage de illos. In le casos de displaciate fracturas alto-transcervical del femore, le union se effectuava lentemente, e secundari manovras chirurgic esseva frequentemente necessari pro obtener coxas functionante. Necrose avascular es un complication frequente de fracturas displaciate. Inter le manos del autor, fixation a clavos multiple non ha succedite in casos de fracturas alto-transcervical del femore a effectuar un fixation rigide que sufficeva a resultar in le prompte adhesion del ossos.

21

Postspinal Anesthesia Osteomyelitis of the Lumbar Spine

P. L. Day, M.D., and J. J. Hinchey, M.D.*

INTRODUCTION

Generally, spinal puncture is regarded as a rather innocuous procedure. Considering the great number done by individuals of varying experience and skill, it is surprising that so few complications are reported.[7] Even after successful, easy puncture, many patients complain of pain in the lower back. Introduction of the needle beyond the neural canal is regarded as the most common cause of persistence of symptoms.[14] The major difficulties following this procedure result from trauma, changes in the cerebrospinal fluid and infection.[4] Dripps[5] reported only 1 instance of incapacitating neurologic disease in a long-term follow-up series of 10,098 spinal anesthetics. This one was shown later to be a meningioma of the spinal cord. He concluded that neurologic sequelae of spinal anesthesia were minor and generally temporary, and that attention to details of technic would result in a much lower incidence of complications.

ANATOMY

The fundamental characteristic of the normal intervertebral disk is its elastic turgidity by which it maintains separation of the vertebral bodies while permitting a certain amount of flexibility.[10] Collapse of the disk is prevented only by the containing capsule, the annulus fibrosis, which, when under increased tension, tends to bulge circumferentially throughout its entire surface. Although generally believed to be avascular, blood vessels within the disk have been found up to the age of 25 years. Nutritive canals have been described which communicate directly with blood vessels of the spongiosa of the vertebral bodies.[2]

In the adult vertebral body there is a bony rim which stands from 1.5 to 2 mm. in height above the surface of the vertebra, partly enclosing the disk anteriorly and laterally but not posteriorly.[11] The nucleus pulposus is situated more posteriorly than centrally. Thus there is a point of weakness posteriorly, due not only to the lack of restraint from the bony rim but also to the fewer folds of fibrous tissue.

In children and young adults, disk injury by lumbar puncture is more likely than in older adults, in whom the structure is smaller, narrower, of less fluid consistency and completely avascular.[1,21]

ETIOLOGY

The importance of injury to the nucleus pulposus was first described by Schmorl in 1927.[16] Others have reported lesions of the intervertebral disks specifically related to lumbar puncture.[6,8,9,12,15]

* San Antonio, Texas.

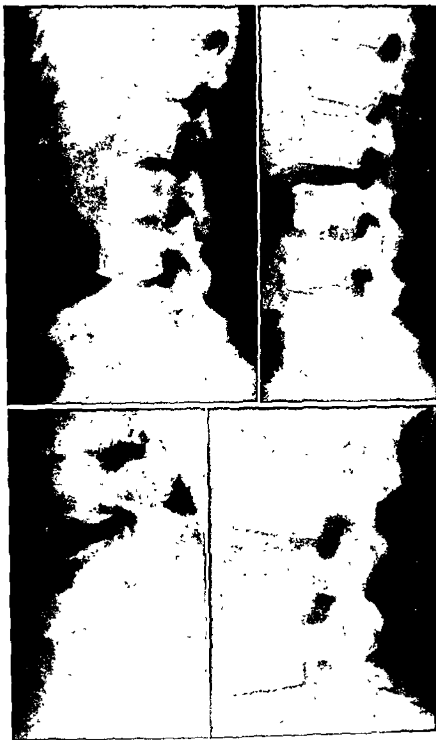


FIG. 1. Case 1. Initial roentgenograms of the early massive destruction of both the disk space and vertebral bodies. Later roentgenograms showing gradual diminution of the joint space between the third and the fourth lumbar bodies and development of fusion over a period of 4 months.

In performance of a lumbar puncture it is sometimes difficult to determine when the point of the needle is actually in the neural canal. It is also difficult to know if the intervertebral disk is penetrated. This may be due to the fact that the annulus is thinner posteriorly and the posterior longitudinal ligament is thinner than the anterior one. Undoubtedly, the flexed position of the spine for lumbar puncture is conducive to perforation of the annulus, which bulges into the neural canal. This position also causes an increase in the intradisk tension in the weaker (posterior) portion. It is possible during lumbar puncture for the needle to carry organisms into the intervertebral disk, or even directly into the vertebra.

SYMPTOMATOLOGY

In a review of the literature in 1949, Bromley and associates found 44 reported cases of injury to the intervertebral disk by

lumbar puncture proved by clinical symptoms and roentgenologic examinations.[3] It is significant that the majority were children. The clinical picture in all was remarkably constant. There was an onset of localized back pain soon after puncture, paravertebral muscle spasm and limited back motion. This was followed by gradual diminution of the intervertebral space and sclerosis of the opposing vertebral bodies.

In our experience, when neurologic symptoms occur, they consist of muscle weakness in the lower extremities, radiating pain into the legs and an abnormal gait.



FIG. 2 Case 2. Roentgenograms showing the typical erosive lesions of the subjacent vertebral bodies of L4 and L5 present 9 months following the lumbar puncture. Stabilization but not solid fusion in this case was the final result.

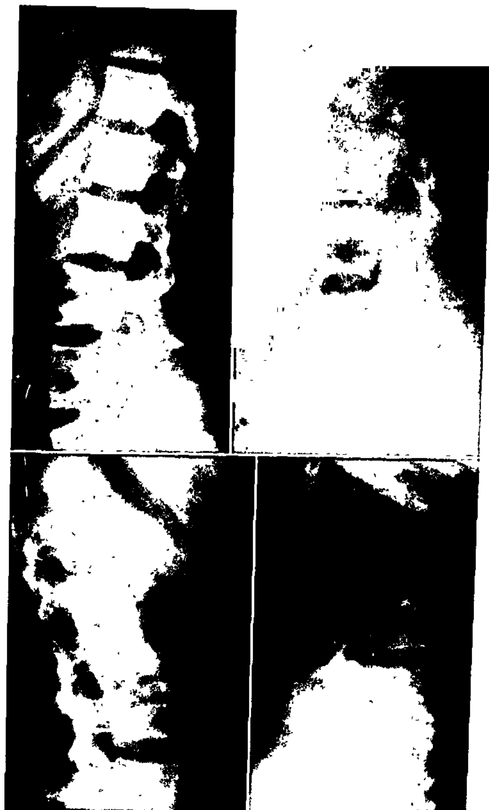


FIG. 3. Case 3. Early negative roentgenograms and later ones showing productive bone changes of the second and the third lumbar vertebrae. Fusion of those infected vertebrae 9 months after spinal puncture. (SIX months after institution of conservative treatment.)

Signs of infection include daily elevation of temperature, well-localized tenderness over the posterior spinous processes of the involved vertebrae[17,18,19] and severe rigidity of the spine, amounting in some instances to a typical "tripod" position.[20,22]

Initial roentgenograms in these cases are negative if taken within a few weeks of the onset of symptoms. Then there is rapid, progressive thinning of the intervertebral disk associated with erosive kissing lesions of the neighboring borders of the infected

vertebrae. After a variable period of time, productive bone changes appear and eventually an attempt at fusion occurs.[13]

CASE REPORTS

Case 1. A woman, aged 32, had a spinal anesthetic for a hysterectomy in May, 1952. This was followed within 1 week by persistent pain at the site of the lumbar puncture. The family physician stated that he had performed the puncture without gloves and had had considerable difficulty in accomplishing it. He suspected an injury or an infection due to the puncture. The patient was rehospitalized in July, 1952, with an obvious destructive lesion of the

FIG. 4. Case 4. Roentgenographic changes occurring at the intervertebral space of L4-5 over a period of 1 year.



lumbar spine confirmed by roentgenograms. Treatment consisted of bedrest, antibiotics and plaster-cast immobilization. A waistline corset replaced the cast at the end of 3 months. At the time of the most recent examination in January, 1957, fusion had occurred and she was asymptomatic except for the limited flexibility of the lumbar spine.

Case 2. A 20-year-old white female had a spinal anesthetic for an appendectomy in August, 1953. The anesthetic was administered by a physician who did not use gloves. Pain developed at the site of the lumbar puncture 1 week later. A roentgenogram of the lumbar spine on November 17, 1953, did not show any abnormality. Back pain persisted, and roentgenograms made on June 7, 1954, showed a destructive intervertebral disk lesion between the fourth and the fifth lumbar vertebrae. Treatment consisted of complete bedrest, antibiotics and immobilization with a back brace.

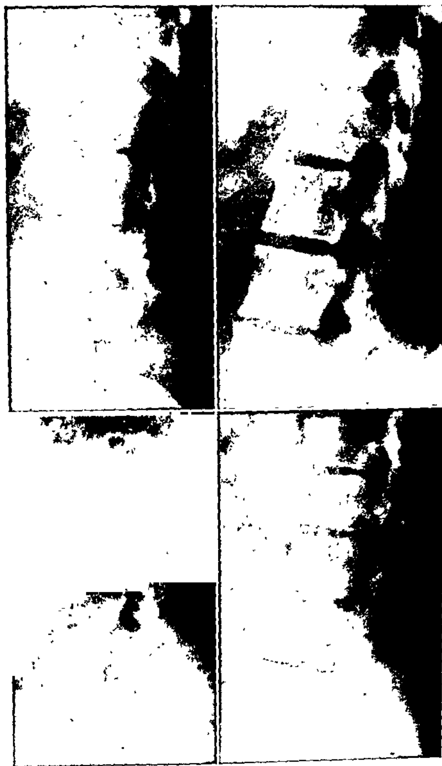


FIG. 5. Case 5. Roentgenograms showing a gradual diminution of the intervertebral space of L2-3 during the treatment program. The usual productive bone changes and spontaneous fusion probably will not occur, since treatment was instituted earlier than in other cases.

The patient was asymptomatic at the time of the most recent examination in February, 1957, except for limited motion of the lumbar spine.

Case 3. A white female, 19 years of age, was operated upon for a pilonidal cyst in November, 1954. A spinal anesthetic was given by a physician who did not use gloves. The site of puncture was prepared with a simple merthiolate cleansing. Roentgenograms of the lumbar spine made on January 3, 1955, did not show evidence of disease The patient presented neurologic symptoms at the time of her initial visit to the clinic, and roentgenograms then showed a destructive lesion of the second and the third lumbar vertebrae. Treatment with bedrest, antibiotics and brace immobilization resulted in complete disappearance of symptoms and solid fusion within a 9-month period.

Case 4. A white male, aged 24, was injured in an automobile accident in December, 1953.

During the treatment period he received multiple diagnostic lumbar punctures. He was unconscious for 2 months and immediately upon regaining consciousness complained of back pain. He was treated by pelvic traction and antibiotics, with improvement, but symptoms recurred in July, 1954. Roentgenograms made 7 months after injury showed a destructive lesion of the fourth and the fifth lumbar vertebrae. Turkel needle biopsy of this lesion revealed only "chronic inflammatory reaction." Later roentgenograms showed progressive thinning of the disk space with sclerosis and productive bone changes.

Case 5. A white female, aged 34, had a hysterectomy performed on October 14, 1955. She was given a spinal anesthetic by a physician who did not wear gloves, and a simple mercurochrome preparation of the area preceded a rather difficult and unsuccessful puncture. Fever, back pain and severe paravertebral muscle spasm were noted on the third postoperative day. Symptoms persisted, and radiographic studies made on February 17, 1956, revealed narrowing of the L2-3 space, which was associated with a "tripod" position and marked tenderness over the posterior spinous processes of these vertebrae. Bedrest, antibiotics and bone immobilization resulted in nearly complete disappearance of symptoms. The patient still is under observation.

SUMMARY

Five cases have been presented with lesions of the lumbar vertebrae following spinal puncture. Four patients had spinal anesthesia for elective surgery, and 1 had diagnostic lumbar punctures. In each instance the diagnosis was delayed by failure to recognize the condition. All have been treated successfully by antibiotics, bedrest and plaster-cast or brace immobilization. None has required operation for this condition, a spontaneous fusion or stabilizing effect having been produced by the conservative management.

CONCLUSIONS

1. It is not our intention here to discourage lumbar puncture for any purpose, whether diagnostic or therapeutic, but rather to call attention to the possibility of a serious major complication.

2. Infection may follow lumbar puncture for two reasons: (1) failure to use an aseptic and accurate technic and (2) traumatic production of a locus minoris resistentiae in the presence of a general body infection with subsequent localization at the site of injury.

The 5 cases presented here probably represent instances of the former, since improper preparation of the patient and difficulty with the procedure prevailed in each case.

3. It is apparent that this rare condition is confined chiefly to the younger-age groups, which is related to the differences in anatomy and physiology present in the disk itself.

4. A diagnosis of postspinal anesthesia osteomyelitis should be considered in any case of persistent pain at the site of a lumbar puncture soon after the puncture. It may be suspected further if local tenderness over the posterior spinous processes is present and daily unexplained fever continues. Rapidly progressive roentgenographic changes of the intervertebral space and adjacent vertebral bodies tend to confirm the diagnosis.

5. Treatment with antibiotics, bedrest and plaster-cast or brace immobilization usually will suffice. Surgical fusion has not been required in the cases presented here.

REFERENCES

1. Baker, A. H.: Lesion of the intervertebral disc caused by lumbar puncture, Brit. J. Surg. 34:385, 1947.
2. Batson, O. V.: The function of the vertebral veins and their role in the spread of metastases, Ann. Surg. 112:138, 1940.
3. Bromley, L. L., Craig, J. D., and Lipman, A. W.: Infected intervertebral disc after lumbar puncture, Brit. M. J. 1:132, 1949.
4. Dripps, R. D., and Vandam, L. D.: Hazards of lumbar puncture, J.A.M.A. 147:1118, 1951.
5. ———: Long-term follow-up of patients who received 10,098 spinal anesthetics, J.A.M.A. 156:1486, 1954.
6. Everett, A. D.: Lumbar puncture injuries, Proc. Roy. Soc. Med. 35:208, 1942.
7. Gellman, M.: Injury to intervertebral discs during spinal puncture, J. Bone & Joint Surg. 22:980, 1940.

8. *Ghormley, R. K., Bickel, W. H., and Dickson, D D*: A study of acute infectious lesions of the intervertebral discs, South. M. J. 33:347, 1940.
9. Guri, J. P.: Pyogenic osteomyelitis of the spine, J. Bone & Joint Surg. 28:29, 1946.
10. Hoen, T. I., Anderson, R. K., and Clare, F. B.: Lesion of the intervertebral disc, S Clin. North America 28:456, 1948.
11. Joplin, R. J.: Intervertebral disc embryology, physiology, pathology, Surg., Gynec. & Obst. 61:591, 1935.
12. Kulaski, J.: Pyogenic osteomyelitis of the spine, J. Bone & Joint Surg. 18:343, 1936.
13. McNutt, J. R.: Roentgen diagnosis of osteomyelitis of the vertebra, Am. J. Roentgenol. 39:52, 1938.
14. Pease, C. N.: Injuries to the vertebrae and intervertebral discs following lumbar puncture, Am J. Dis. Child 49:849, 1935.
15. Redlich, F. C., and Moore, B. E.: Lumbar puncture reactions, Psychosom. Med. 8: 386, 1946.
16. Schmorl: Über die an den Wirbelband Scheiben vorkommenden Ausdehnungen und Zerreissungsvorgänge und die dadurch an ihnen und der Wirbel Spongiosa hervorgerufenden Veränderungen, Verhandl deutsch. Path. Gesellsch. 2:250, 1927.
17. Sherman, M., and Schneider, G. T.: Vertebral osteomyelitis complicating postabortal and postpartum infection, South. M. J. 48:333, 1955.
18. Smith, A. D.: A benign form of osteomyelitis of the spine, J.A.M.A. 101:335, 1933.
19. Steindler, Arthur: Osteomyelitis of the spine, J. Iowa M. Soc. 20:246, 1930.
20. Volkmann: Uber die primäre akute und subakute Osteomyelitis Purulenta der Wirbel, Deutsche Ztschr. Chir. 132:445, 1915.
21. Waggoner, G., and Pendergrass, E. P.: Intrinsic circulation of the vertebral body, Am. J. Roentgenol. 27:818, 1932.
22. Wilensky, A. O.: Osteomyelitis of the vertebrae, Ann. Surg. 89:561, 731, 1929.

Osteomyelitis del Spina Lumbar Post Anesthesia Spinal

Summario in Interlingua

Es presentate cinque casos de lesiones del spina lumbar post anesthesia spinal. Quatro del patientes habeva recipite anesthesia spinal pro chirurgia elective. Le quinte habeva essite subjicite a un punctura lumbar diagnostic. In omne le cinque casos le diagnose esseva retardate pro septimanas o menses in consequentia de non-recognition del condition. Omne le casos esseva tractate a bone successo con antibioticos, allectamento, e immobilisation per apparatos gypsate o orthopedic. Nulle requireva un intervention chirurgic pro iste condition. Fusion spontanee o un effecto stabilisatori esseva producite per un tractamento conservatori.

Anatomia

Le characteristica fundamental del normal disco intervertebral es su turgiditate elastic que rende lo capace a mantener le separation del corpores vertebral sin prohibir un certe grado de flexibilitate. Le collapso del disco es prevenite solmente per le capsula in que illo es continite, i.e., le anulo fibrose. Quando subjicite a un augmento de tension, iste anulo tende a protruder circumferentialmente a su integre superficie. Ben que il es generalmente acceptate que le discos es avascular, vasos sanguinee intra illos ha essite incontrate in individuos usque al etate de vinti-cinque annos, e canales nutritive ha essite describite que establiva un communication directe inter le discos e vasos sanguinee del spongiosa del corpores vertebral.

Physiologia

In le adulte corpore vertebral on trova un margine ossee que ascende a inter 1,5 e 2 mm supra le superficie del vertebra Illo include le disco anterior- e lateralmente sed non posteriormente.[6] Le nucleo pulpose es situate plus posterior- que centralmente, e il existe in iste loco un puncto de debilitate que resulta non solmente del absentia de

supporto per le margine ossee sed etiam del numero reducite de *plicas de histo fibrose.*

In juveniles e juvene adultos lesiones del discos in consequentia de punctura lumbar es plus probabile que in adultos de etates plus avantiate in qui le structura es plus micre, minus late, de un consistentia plus fluide, e completemente avascular.[7,8]

Etiologia e Symptomatologia

In le execution de un punctura lumbar pro non importa qual ration, il es difficile determinar quando le puncta del agulia es de facto intra le canal neural, proque le reduction del resistentia quando le canal es attingite non es identic in omne casos. Il es etiam difficile recognoscer si o non le disco intervertebral *ha essite penetrate. Istos* es possibilemente conditionate per le facto que le *anulo es plus tenue posteriormente* durante que le ligamento longitudinal posterior es plus tenue que le ligamento anterior. Le postura flexionate pro punctura lumbar resulta in le risco de perforation del anulo que protrude a in le canal neural durante que le tension intra le disco es augmentate in su portion le minus *forte, i.e., le portion posterior.* Il es possibile in puncturas lumbar que le *agulia porta* organismos ab le histos perforate a in le disco intervertebral o directemente a in le vertebras.

In lor revista del litteratura, Bromley et al. trovava in 1949 reportos de quaranta-quatro casos de lesiones de un disco intervertebral *in consequentia de punctura lumbar.* Omne istos esseva documentate clinica- e radiologicamente. Le *majoritate* del casos concerneva juveniles.[9] Le aspecto clinic esseva remarcabilemente constante. Tosto post le punctura il habeva un declaration de localisate dolores dorsal, spasmo de musculo paravertebral, e reduction del motion dorsal, sequite per un diminution gradual del spatio intervertebral e sclerose del adjacente corpores vertebral.

*In nostre experientia, le symptomas neu*rologic que occurre consiste de debilitate muscular in le extremitates inferior con radiation del dolores a in le gambas e un ambulatura anormal.

Le signos del presentia de infection include le elevation diurne del temperatura, ben localisate sensibilitate supra le processos spinose del vertebras afficite, e sever rigiditate spinal que amonta in certe casos a un typic position tripodic. In tal casos, le *roentgenogrammas initial es negative si illos* es facite intra alicun septimanas post le *declaration del symptomas. Il* occurre, tamen, un rapide e progressive tenuification del disco intervertebral, associate con lesiones erosive del margines adjacente in le vertebras afficite. Isto es sequite post un intervallo de duration variabile per leve grados de productive alterationes ossee in le curso tempore per le essayo de effectuar fusion.

22

A New Method of Pelvic Fixation

WILLIAM JOHNSON, M.D.*

The speed age in which we now live is responsible for situations that in past decades were encountered only infrequently. Comminuted pelvic fractures, in which half the pelvis is avulsed from the other half and from the sacrum, show an increasing incidence.

Automobiles today resemble eggs which on impact spew their contents in all directions. Often, as a result of a crash, the car will eject its occupants and then roll over. If an occupant is lying on his side as the car rolls over him, he will be caught in the jaws of a giant nutcracker.

Four of the injuries on which this report is based occurred in this manner. All the injuries to the pelvis followed a rather definite pattern (Fig. 1). Posteriorly, the sacro-iliac joint was avulsed, fracturing a portion of the sacrum or the ilium in that area. Anteriorly, both rami of the ischium and the pubes were fractured on either one or both sides, so that the entire coxal bone on the one side was separated from its attachment to the opposite side.

Dr. J. Grant Bonnin, of the Central Middlesex Hospital, in England, said that from the mechanical aspects there are 3 zones of weakness in the pelvis: the anterior zone, including the pubic symphysis; the central



FIG. 1 Pelvic fracture showing avulsion of the sacro-iliac joint, fracture of ilium and both rami, ischium and pubis.

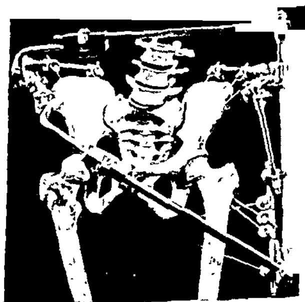
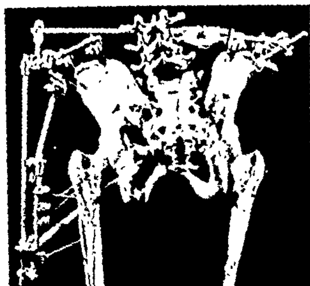


FIG 2. Pelvic fixation in place showing placement of pins, bars and clamps.

* The Galesburg Clinic, Galesburg, Ill.



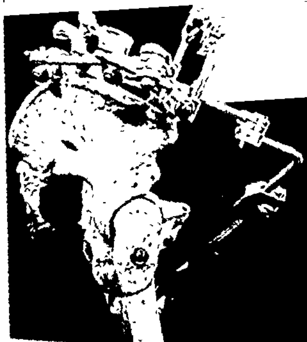


Fig. 3. Control of pelvic fragments from outside of body possible by means of bars, clamps and turnbuckle.

zone, with a weak acetabular floor; and the posterior zone, comprised of the sacro-iliac joint, the ala of the ilium and the lateral mass of the sacrum.

No reference will be made here to the numerous injuries to any pelvic structures other than the bony pelvis.

Having treated several fractures of this character by conventional methods with unsatisfactory results, I concluded that a method of grasping the bony pelvis in some



Fig. 4. Pins placed in both iliac crests and subtrochanteric area or pubic ramus. When connected with bars and clamps, a triangle is formed, preventing pin travel.

rigid, positive manner was necessary to relocate these fragments in their anatomic position (Fig. 2). An idea was worked out on a pelvic skeleton. I discovered that the ileum would receive and hold pins up to $\frac{5}{32}$ inch in size when these pins were directed downward and medially. By placing a cluster of 3 pins in each iliac crest and attaching them by means of clamps and bars to other pins placed in the pubic ramus or subtrochanteric areas, it was evident that these fragments could be controlled from outside the body (Fig. 3). An old device, the turnbuckle, then was attached to the fixation units described above to enable me to move the fragments into their correct position. The pins had to be directed in the proper plane through the soft tissues so that there was no pile-up and resultant necrosis of these tissues on one side of the pin (Fig. 4).

The pins were so placed that when connected with each other by means of the clamps and bars, they formed a triangle. This prevented pin travel (Fig. 5). Movement of the pins in the soft tissue was eliminated by firm gauze or felt round the pins.

Subtrochanteric fixation on the well side and the resultant locking of the hip joint provided a low anchor point for an oblique

bar or turnbuckle, allowing rotation of the ilium in the transverse plane (Fig. 6).

Open reduction of fragments that have strayed too far away may sometimes be necessary. A modified Fanenstel type of incision, Fanenstel superpubic incision, permits exploring the bladder and bringing the strayed fragments back home. Rigid fixation lessens shock. Final reduction may be delayed for a few days, but, lest one waits too long, it should be remembered that the membranous bone heals very rapidly.

The following case reports illustrate this procedure:

Mr. K. S. On December 27, 1955, a 22-year-old white male was admitted directly to the operating room following an automobile accident in which the car had rolled over onto him. Injuries sustained were dislocation of the left hip joint, multiple fractures of the pelvis, symphysis widely separated, separation of sacro-iliac attachments and multiple fractures of the sacrum. The patient was in extreme shock and was conscious. Blood pressure 0; pulse, imperceptible.



Fig. 5. Movement of pins in soft tissue prevented by felt or gauze.



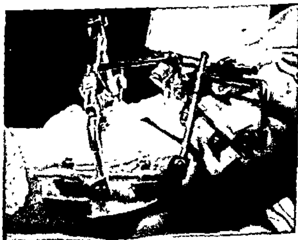


Fig 6 Hip joint locked, permitting rotation of ilium in the transverse plane.

Dextran 500 cc. containing 250 mg. cortisone was given intravenously immediately. The patient responded, his color improved, and blood pressure rose to 40/0.

Because immediate surgery was deemed to be imperative, Pentothal Sodium anesthetic was started. During surgery, color remained satisfactory and blood pressure rose to 50/0. Two pints of blood was given following dextran solution, and the patient's condition at the close of surgery was classified as fair.

Operative procedures were as follows:

A catheter was passed through the urethra without difficulty and placed in the bladder (the urine was bloody). The dislocated left hip was reduced without difficulty by manipulation. A Fanenstel transverse lower abdominal incision was made through skin and subcutaneous tissue. A longitudinal mid-line incision was made through the fascia. The peritoneum was not opened. The bladder was opened and explored. No laceration was found. The bladder then was closed with 2 layers of chromic 4-0 suture The right symphysis was explored. A bone fragment was found to be displaced 3 inches laterally and posteriorly. It was brought into position with a hook retractor. The pelvis was fixed with a 3-pin unit in crest of each ilium and a 2-pin unit on each side of the pubis. Under direct palpation the fragments were maneuvered into place and held by external fixation. A hematoma on the left side of the pelvis and behind the peritoneum was evacuated. One million units of penicillin was instilled into this area. The incision was closed. The patient was put to bed with traction on both legs.

The patient developed steady, progressive renal failure. On December 30, 1955, he received 1 pint of blood, and a spinal tap was done because of evidence of cerebral damage, which was verified by the spinal puncture. The spinal fluid showed a total protein of 172.0 mg. per cent.

The patient died on January 8, 1956, due to bilateral bronchopneumonia of the lower lobe; acute dilatation of the right heart; pulmonary edema; contusion of both kidneys with focal necrosis in the cortical zones; extensive retroperitoneal hemorrhages, multiple fractures of the pelvis; mild cerebral edema (Fig 7).

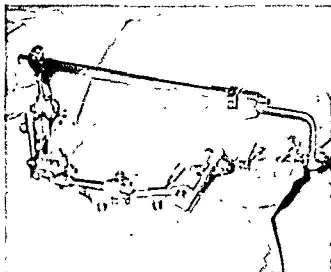


FIG. 7. Mr. K. S. Fracture of right symphysis reduced and fixed with pins in each crest of the ilium and both sides of the pubis.

Miss M. J. R. On December 11, 1953, a 5-year-old white female was admitted to the hospital following an automobile accident in which the car had rolled over onto her. She was in shock and in critical condition. First aid was given. She was put to bed and treated for shock. Bedside roentgenograms, taken the next day, showed multiple fractures of the pelvic arch, particularly on the left, where ischium and pubis were comminuted; on the right the pubis was partially fractured near the symphysis, possibly at the acetabulum. The left acetabulum was separated at the suture line, and the left sacro-iliac joint was subluxated superiorly. Several opaque foreign bodies appeared in the soft tissue of the pelvis

A tear into the vagina was treated, and an indwelling catheter was used for several days. Buck's extension was applied bilaterally.

Recheck roentgenograms, taken 3 days later, revealed no essential change in position of any of the fragments of the anterior pelvis. The left sacro-iliac still was subluxated with the innominate bone cephalad.

Reduction with external fixation was done on December 23. A dual pin unit was placed in the ala of each ilium, and 2 pins were placed through the proximal left femoral shaft. External fixation then was applied. Postoperative roentgenograms revealed that the left pubic ring fragments were improved in position and that the subluxation of the left sacro-iliac joint was reduced to almost normal position. Lateral view showed the left half of the symphysis to be normal. On January 3, 1954, a Roger Anderson unit was used on the fixation bars. Check roentgenograms showed improved position of the left innominate bone, but about 5° of medial rotation still remained.

Three days later the patient was sitting up in a chair. Interval pain remained in left leg at that time. Two days later she walked 3 steps; from that time on her daily walking distance increased, and her leg usage improved.

Roentgenograms taken on January 15 and 25 showed no change in relative position of the fragments of the left pelvis, pins or bars from the last examination. There was early callus, appearing along all fracture lines.

Pins and external fixation were removed on February 1, 5½ weeks from date of insertion. Roentgenograms after pin removal showed no change in relative position of fracture fragments. The patient began daily tub baths and passive exercise. On February 11, exactly 2 months from date of admission, she was discharged from the hospital. Follow-up care at the Clinic included daily physiotherapy for a period of 3½ months

Roentgenograms on April 19 revealed that the normal concavity of the pelvis was lost on the left. The ischium and the pubic fractures were healed solidly, the acetabulum was well healed, and the head of the left femur was normal as compared with the right. There was no evidence of aseptic necrosis, nor was there any traumatic arthritis of the left hip joint.

Patient had normal abduction, normal flexion of thighs on abdomen, normal internal and external rotation, right leg 23½ inches, left leg 23½ inches. Patient was discharged from treatment on April 22, 1954.

The patient returned for roentgenograms and inspection on April 8, 1955. Report on roentgenograms. anteroposterior and lateral views taken of the pelvis reveal that the left pelvis now is solidly healed; there is some medial angulation at the junction of ilium and ischium and pubis through the acetabulum; the acetabulum is smooth, and the head of the femur is normal.

Mrs. W. T. On January 15, 1956, a 25-year-old white female, weighing 245 pounds, was admitted to the hospital following an automobile accident in which the auto overturned onto her, injuring her pelvis and back. Arthrosis of the left knee joint was noted also, and the patient was in shock on her arrival at the hospital. First aid was given, and she was put to bed Roentgenograms taken 2 days later read: anteroposterior views of the lumbar spine and pelvis show a fracture through the superior and the inferior pubic rami on both sides, a fracture through the left acetabulum and a separation laterally of the right sacro-iliac joint of about 2 cm. The pubic fragments on the right are somewhat similar to the sacro-iliac joint. The lumbar vertebrae appear to be intact.

The patient was placed in pelvic traction with Buck's extension to the right leg. Because routine laboratory work revealed a mild anemia, 2 pints of blood was given within a 10-day period.

Roentgenograms taken on January 24 and again on January 30 showed no improvement in position of the fragments On February 7, external fixation was applied in the following manner: a triple-pin unit was inserted into the ala of each ilium, and the dislocation of the right side of the pelvis was reduced by means of 2 turnbuckle bars connecting the pin units and immobilizing the pelvis. The anterior central fragments could not be reduced anatomically because of early callus formation. Repeated follow-up roentgenograms showed the sacro-iliac joints remaining in normal relationship, and the fractures of the left anterior pelvis were in good apposition and alignment.

On May 5, 12½ weeks after their application, the pins and the external bars were removed Roentgenograms taken 2 weeks later showed no change in the relative position of the fragments of the right anterior pelvis Early callus was seen for the first time. The body of the right ilium remained in its same relationship to the sacrum.

During the patient's stay in the hospital she was on an 800-calorie diet and was on thyroid grains 1 daily. She was discharged on May 24, 18 weeks from day of admission, and had lost a total of 61 pounds. She continued on thyroid grains 1 daily at home.

The patient was seen at the Clinic on June 2. At that time she was walking fairly well but was complaining of moderate pain in the right hip. She also had swelling of the lower extremities, a condition that moderated and disappeared as she continued to lose weight.

On June 30 the patient was symptom free. Roentgenograms taken at that time and in full weight-bearing position showed no change in the position of the sacro-iliac joint on the right, nor of the fracture of the ischium and the pubis on the right.

She was discharged from orthopaedic care 1 month later, 7 months from the date of accident (Fig 8).

Mrs. B. W. The patient was a well-developed, well-nourished white female, aged 24, the driver of a car that was involved in an ac-



FIG. 8 Illustrating that this method of external fixation can be applied to the very obese patient.

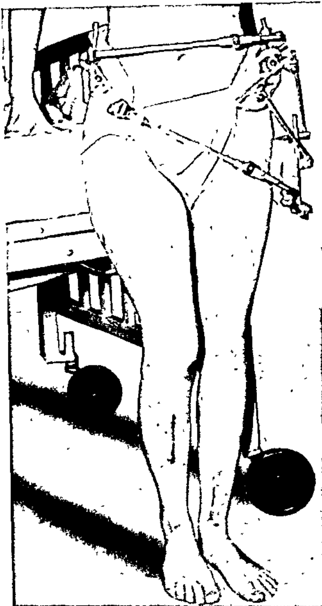


FIG. 9. Illustrating this method of external fixation for the patient of moderate proportions.

cident on May 23, 1951, when the car overturned onto the patient She was taken to the hospital in severe shock. She had scalp lacerations, numerous bruises and abrasions, and multiple fractures of the pelvis. First aid was given, and the patient was put to bed.

Roentgenograms: bedside views of the pelvis revealed multiple fractures; on the right anteriorly, fractures of the superior ramus of the ischium and the inferior ramus of the pubis; on the left, a comminuted fracture of the superior pubic ramus and a linear fracture of the inferior pubic ramus Posteriorly, a fracture of the right first and second sacral segments, subluxation of the right sacro-iliac joint with superior displacement, and fracture of the right fourth and fifth transverse processes

Bladder and bowel were intact.

On May 26, under Penthothal Sodium anesthesia, 3 pins were placed in each innominate bone and joined to each other with clamps and bars

A dual half pin unit was placed in the upper femur on the left. The left innominate bone and the left femur were fixed to each other by means of 2 external bars, thus locking the left hip joint.

The loose right half of the pelvis was fixed to the rigid left half of the pelvis and the upper femur by means of 2 turnbuckle bars. Adjustments were made after repeated roentgenograms were studied, and satisfactory reduction was obtained.

On June 7, the turnbuckles were locked by means of set screws.

The bladder was kept decompressed for 1 week with a retention catheter; the urine was negative for blood.

The patient was allowed to walk, using a

walker, on June 12, 17 days after pinning and experienced no pain.

On June 23, she developed cystitis, which was controlled by antibiotics, and on June 28 was flown from Galesburg, Ill. to Omaha, Neb., in an Army Hospital plane and admitted to the Army Air Force Hospital. The flight was uneventful.

Progress, as described by Captain George Pester, Chief of Surgical Service, follows:

"Postoperative course was very uneventful. Pins were removed from the pelvis and the left femur under morphine sedation. There was no evidence of inflammation round any of the pins. Patient now is fully ambulatory and walks fairly well without the use of a walker. Dismissed on July 26. To be followed as an outpatient" (Fig. 9).

Mr. L. O. On August 2, 1956, a 29-year-old white male was admitted to the hospital after falling approximately 35 feet from a bar joist. He was semiconscious, answered questions slowly and did not remember how the accident happened. The pupils were equal and regular with normal light reaction. Obvious injuries were abrasions of left forehead and left hand, contusion and laceration of left elbow. He complained of lower back pain.

Roentgenograms of the pelvis revealed a dislocation of the left pelvis, a separation through the symphysis pubis and a separation through the left sacro-iliac joint. Roentgenograms of the left arm showed a fracture through the head of the radius with displacement. The patient underwent surgery in which the fractures were reduced in the following manner:

Three pins were inserted into the ala of each ilium. These were connected by 2 turnbuckle bars which were shortened and fixed, thus reducing the pelvic dislocation. A cast was applied to the left arm from metacarpals to axilla with arm in flexion.

Postoperative roentgenograms showed excellent reduction and immobilization of the separation of the symphysis pubis and of the dislocated left sacro-iliac joint. Convalescence was uneventful. The arm cast was removed about 6 weeks after its application. The pins were removed from the pelvis on October 18, or about 2½ months from date of insertion. The patient was dismissed from the hospital on October 22.

On October 29, the patient returned to the office for an examination. He stated that he walked from 10 to 12 blocks twice daily. He complained of soreness in the lower back and the back of the thighs. The treatment was sacro-iliac belt, diathermy and massage.

The patient was seen on December 28, 1956, for an evaluation examination. He complained of persistence of soreness in left buttock and to the left of lower end of sacrum Had the feeling of a "rubbing together" somewhere in the pelvis when he turned over in bed. Rotation of trunk on pelvis suddenly caused pain in pelvis. He also complained of a stabbing sensation sporadically on the lateral aspect of the left thigh. Occasionally, pain would extend down to left knee. He could stoop over until the hands were 7 inches from the floor. He could sit on his haunches completely and normally. The pelvis appeared to be symmetric. The lower extremities were equal circumferentially. In the roentgenograms taken on December 28, 1956, the symphysis pubis appeared to be normal in appearance The sacro-iliacs, both right and left, were equal There was no displacement upward of the wing of the ilium at the sacro-iliac joint. The patient had a 20 per cent disability of the pelvis

SUMMARY

A new type of severe pelvic fracture has appeared as a result of the speed age—the nutcracker fracture. A new type of fixation has been applied to restore anatomic relationships of through-and-through pelvic fracture. I have also presented pictures of the mechanics involved in this type of injury and the technic of inserting the pins and applying the external fixation apparatus, as well as of patients with fixation apparatus in position.

Un Nove Methodo de Fixation Pelvic

Summario in Interlingua

Le "epocha de velocitate" in que nos vive ha generate plure typos de non previemente cognoscite situationes. Comminutive fracturas pelvic, in que un medietate del pelve es avellite ab le altere e ab le sacro, es un phenomeno de crescente incidentia resultante del velocitate de nostre epocha.

Nostre automobiles es como ovos que—post impacto—spue lor contento in omne directiones. Le effecto de un collision es frequentemente que le auto ejice su occupantes ex su interior e continua rolar. Si un del occupantes jace super su latere durante que le auto rola a transverso de ille, su corpore se trova capturate inter le terra e le peso del vehiculo, inter le maxillas de un gigante rumpe-nuces.

Omne le vulnerationes hic reportate sequeva un definite schema. In le vista posterior, le articulation sacro-iliac esseva avellite, e portiones del sacro e del ilio in ille area esseva fracturate. In le vista anterior, ambe ramos del ischio e del pube esseva fracturate a un o ambe lateres, de maniera que le integre osso coxal a un latere esseva separate ab su attachamento al latere opponite.

Le ilio accepta e retene clavos de usque al dimension de $5/32$ pollices si lor direction es in basso e central. Per placiar un gruppo de tres clavos in cata cresta iliac e attachar los per medio de crampas e barras a altere clavos placiate in le ramo pubic o le area sub-trochanteral, il esseva evidentemente possibile regularisar le fragmentos ab foras del corpore. Un tensor a vites esseva attachate al clavos pro render possibile le remotion del fragmentos verso lor position normal. Il esseva importante diriger le clavos appropriatemente a transverso le histo molle de maniera a evitar un accumulation de iste histo a un latere del clavos con le risco consequente de necrosis.

Le clavos esseva placiate de maniera que illos formava un triangulo post lor interconnexion per crampas e barras. Isto preveniva omne migration del clavos. Movimentos del clavos in le histo molle esseva eliminate per paccos de gaza o feltro.

Fixation sub-trochanteral executate de maniera a effectuar blocage del articulation coxal provideva un basse puncto de ancorage pro un barra oblique o un tensor a vites con le possibilitate de rotar le ilio in le plano transverse.

Le reduction aperte de fragmentos a displaciamento troppo grande es possibilemente inevitabile in certe casos. Un typo modificate del incision de Pfannenstiel—le incision super-pubic de Pfannenstiel—permitte explorar le vesica e retornar le displaciate fragmentos. Fixation rigide reduce le choc. Le reduction final pote esser retardate per alicun dies, sed il es importante non oblidar que le osso membranose se regenera rapidissimemente.

Es reportate quatro casos pro illustrar iste methodo de fixation pelvic. Omnes succedeva.

23

Metastasis to Bone from Carcinoma of the Breast

PAUL D. ZIMSKIND, M.D., AND JAMES M. SURVER, M.D.

Metastatic neoplasms in bone are those malignant tumors which originate outside the skeleton and spread to it by way of the blood stream or the lymphatic channels, or by direct extension (Stein *et al.*, 1955). This chapter attempts to review and add to the body of literature concerning metastases to bone from carcinoma of the female breast, based on a study of patients seen in the Tumor Clinic of the Jefferson Medical College Hospital.

MATERIAL

Ninety-four Tumor Clinic patients with carcinoma of the breast which had produced 199 metastatic lesions in bone were investigated. In 77 of these (81.9%), diagnosis of the primary lesion was made by histopathologic examination; 15 (16.0%) were diagnosed clinically; and in 2 cases (2.1%) the method of diagnosis was not recorded. Various stages in the clinical courses of these patients were noted and subjected to statistic analysis, the results of which will be presented and discussed subsequently.

INCIDENCE

According to Willis (1952), the skeleton represents one of the most frequent sites of tumor metastasis, surpassed only by the lungs and the liver. With regard to the frequency of osseous metastases arising from primary lesions in the breast, Bloodgood (1920) found the breast to predominate over all other sites. Toumey (1943) observed that metastases to the spine in the female most frequently arise from breast neoplasms. Salzman (1954) combined scattered data in the literature and Lahey Clinic material with the incidence of the various cancers in the population and found carcinoma of the breast to be responsible most frequently for skeletal metastases in female patients. Likewise, Abrams (1950), in a projected calculation derived by multiplying the incidence of breast carcinoma per 100,000 general population by the percentage of skeletal metastases resulting from breast cancer in his autopsy series (84%), found the breast to be the most common source of bone metastasis in both the female and the general population.

The incidence of bone metastasis in breast cancer has been reported to occur in varying frequencies. Geschickter and Copeland (1949) observed it in 5.2 per cent of 1,194 cases; however, many of these patients had not reached the 5-year period. Willis (1952), on the other hand, states that osseous metastases occur in about one half of fatal cases. Bone lesions from breast neoplasms were found in 42.6 per cent of 162

cases by Warren and Witham (1933), in 81 of 168 cases (48.2%) by Lenz and Freid (1931), and in 57.1 per cent of 105 cases studied by Turner and Jaffe (1940). Willis (1952) points out that the incidence of skeletal metastases cited in fatal cases must necessarily be too small since it is impracticable to examine completely the entire skeleton in routine postmortem work and many metastatic growths are asymptomatic and thereby escape discovery.

Age does not seem to play a significant role in regard to the incidence of bone metastasis from breast carcinoma. The rate of frequency follows the usual curve of incidence of the primary lesion, with no evident deviation toward the younger-age groups (Wulff, 1939; Bouchard, 1945; Rennes, 1952). Wulff found 60 per cent of cases to fall within the age range of 40 to 60, with lower and upper limits of 27 and 78 years. Within this age range Lenz and Fried (1931) eported an incidence of 56 per cent of their ases Bouchard found the average age of nset of bone metastasis to be 44.4 years, the e varying from 24 to 77 years. Geschickter d Copeland (1949) reported the majority - bone lesions as occurring between the ages of 35 and 55, the extremes in age being 21 and 73. The findings in the present series are in substantial agreement with those cited, and are shown in Table 1. It can be seen that 58.5 per cent of cases of bone metastasis fell within the age range of 40 to 60 years. The average age of patients was 53.1 years, the ages ranging from 33 to 76 years.

TABLE 1. AGE DISTRIBUTION IN 94 CASES OF CARCINOMA OF THE BREAST WITH METASTASIS TO BONE

AGE RANGE	NO. PATIENTS	PER CENT
21-30...........	1	1.1
31-40...........	17	18.1
41-50...........	23	24.4
51-60...........	32	34.1
61-70...........	15	15.9
71-80...........	6	6.4
	94	100.0

CHARACTERISTICS OF THE PRIMARY LESION

There appears to be no significant relationship between the quadrant localization of the primary tumor in the breast and the incidence of subsequent bone metastasis (Bouchard, 1945; Staley, 1956).

Staley conducted an analysis of the clinical characteristics of the primary breast lesion in patients who developed osseous metastases and in those who did not. Fixation of the tumor to the skin was noted in 85 per cent of the former group of patients and in 76 per cent of the latter group. In 80 per cent of the former group the mass was greater than 3 cm., while 68 per cent exhibited such a mass in the latter. Positive axillary nodes were found in 61 per cent and 45 per cent, respectively.

ROUTES OF METASTASIS

Skeletal metastasis from carcinoma of the breast occurs by direct extension to adjacent bone and by lymphatic and blood-stream dissemination to more distant sites. There is controversy as to which of the latter two routes predominates. Handley, in 1922, hypothesized that the skeletal metastases of mammary cancer arose from extensions into the bone from permeation of cancerous cells through the adjacent deep fascial lymphatic plexuses. Carnett and Howell (1930) expressed agreement with this hypothesis, citing the orderly extension of cancer in bones which they observed as being incompatible with any mode of spread other than lymphatic permeation. In addition, the usually mottled appearance of bone which they noted in the earliest stage of invasion of bone anywhere was indicative to them of multiple foci of cancer developing simul-

23

Metastasis to Bone from Carcinoma of the Breast

PAUL D. ZIMSKIND, M.D., AND JAMES M. SURVER, M.D.

Metastatic neoplasms in bone are those of malignant tumors which originate outside the skeleton and spread to it by way of the blood stream or the lymphatic channels, or by direct extension (Stein *et al.*, 1955). This chapter attempts to review and add to the body of literature concerning metastases to bone from carcinoma of the female breast, based on a study of patients seen in the Tumor Clinic of the Jefferson Medical College Hospital.

MATERIAL

Ninety-four Tumor Clinic patients with carcinoma of the breast which had produced 199 metastatic lesions in bone were investigated. In 77 of these (81.9%), diagnosis of the primary lesion was made by histopathologic examination; 15 (16.0%) were diagnosed clinically; and in 2 cases (2.1%) the method of diagnosis was not recorded. Various stages in the clinical courses of these patients were noted and subjected to statistic analysis, the results of which will be presented and discussed subsequently.

INCIDENCE

According to Willis (1952), the skeleton represents one of the most frequent sites of tumor metastasis, surpassed only by the lungs and the liver. With regard to the frequency of osseous metastases arising from primary lesions in the breast, Bloodgood (1920) found the breast to predominate over all other sites. Toumey (1943) observed that metastases to the spine in the female most frequently arise from breast neoplasms. Salzman (1954) combined scattered data in the literature and Lahey Clinic material with the incidence of the various cancers in the population and found carcinoma of the breast to be responsible most frequently for skeletal metastases in female patients. Likewise, Abrams (1950), in a projected calculation derived by multiplying the incidence of breast carcinoma per 100,000 general population by the percentage of skeletal metastases resulting from breast cancer in his autopsy series (84%), found the breast to be the most common source of bone metastasis in both the female and the general population.

The incidence of bone metastasis in breast cancer has been reported to occur in varying frequencies. Geschickter and Copeland (1949) observed it in 5.2 per cent of 1,194 cases; however, many of these patients had not reached the 5-year period. Willis (1952), on the other hand, states that osseous metastases occur in about one half of fatal cases. Bone lesions from breast neoplasms were found in 42.6 per cent of 162

cases by Warren and Witham (1933), in 81 of 168 cases (48.2%) by Lenz and Freid (1931), and in 57.1 per cent of 105 cases studied by Turner and Jaffe (1940). Willis (1952) points out that the incidence of skeletal metastases cited in fatal cases must necessarily be too small since it is impracticable to examine completely the entire skeleton in routine postmortem work and many metastatic growths are asymptomatic and thereby escape discovery.

Age does not seem to play a significant role in regard to the incidence of bone metastasis from breast carcinoma. The rate of frequency follows the usual curve of incidence of the primary lesion, with no evident deviation toward the younger-age groups (Wulff, 1939; Bouchard, 1945; Rennes, 1952). Wulff found 60 per cent of cases to fall within the age range of 40 to 60, with lower and upper limits of 27 and 78 years. Within this age range Lenz and Fried (1931) reported an incidence of 56 per cent of their cases. Bouchard found the average age of onset of bone metastasis to be 44.4 years, the age varying from 24 to 77 years. Geschickter and Copeland (1949) reported the majority of bone lesions as occurring between the ages of 35 and 55, the extremes in age being 21 and 73. The findings in the present series are in substantial agreement with those cited, and are shown in Table 1. It can be seen that 58.5 per cent of cases of bone metastasis fell within the age range of 40 to 60 years. The average age of patients was 53.1 years, the ages ranging from 33 to 76 years.

TABLE 1. AGE DISTRIBUTION IN 94 CASES OF CARCINOMA OF THE BREAST WITH METASTASIS TO BONE

AGE RANGE	NO. PATIENTS	PER CENT
21-30	1	1.1
31-40	17	18.1
41-50	23	24.4
51-60	32	34.1
61-70	15	15.9
71-80	6	6.4
	94	100.0

CHARACTERISTICS OF THE PRIMARY LESION

There appears to be no significant relationship between the quadrant localization of the primary tumor in the breast and the incidence of subsequent bone metastasis (Bouchard, 1945; Staley, 1956).

Staley conducted an analysis of the clinical characteristics of the primary breast lesion in patients who developed osseous metastases and in those who did not. Fixation of the tumor to the skin was noted in 85 per cent of the former group of patients and in 76 per cent of the latter group. In 80 per cent of the former group the mass was greater than 3 cm., while 68 per cent exhibited such a mass in the latter. Positive axillary nodes were found in 61 per cent and 45 per cent, respectively.

ROUTES OF METASTASIS

Skeletal metastasis from carcinoma of the breast occurs by direct extension to adjacent bone and by lymphatic and blood-stream dissemination to more distant sites. There is controversy as to which of the latter two routes predominates. Handley, in 1922, hypothesized that the skeletal metastases of mammary cancer arose from extensions into the bone from permeation of cancerous cells through the adjacent deep fascial lymphatic plexuses. Carnett and Howell (1930) expressed agreement with this hypothesis, citing the orderly extension of cancer in bones which they observed as being incompatible with any mode of spread other than lymphatic permeation. In addition, the usually mottled appearance of bone which they noted in the earliest stage of invasion of bone anywhere was indicative to them of multiple foci of cancer developing simul-

23

Metastasis to Bone from Carcinoma of the Breast

PAUL D. ZIMSKIND, M.D., AND JAMES M. SURVER, M.D.

Metastatic neoplasms in bone are those malignant tumors which originate outside the skeleton and spread to it by way of the blood stream or the lymphatic channels, or by direct extension (Stein *et al.*, 1955). This chapter attempts to review and add to the body of literature concerning metastases to bone from carcinoma of the female breast, based on a study of patients seen in the Tumor Clinic of the Jefferson Medical College Hospital.

MATERIAL

Ninety-four Tumor Clinic patients with carcinoma of the breast which had produced 199 metastatic lesions in bone were investigated. In 77 of these (81.9%), diagnosis of the primary lesion was made by histopathologic examination; 15 (16 0%) were diagnosed clinically; and in 2 cases (2.1%) the method of diagnosis was not recorded. Various stages in the clinical courses of these patients were noted and subjected to statistic analysis, the results of which will be presented and discussed subsequently.

INCIDENCE

According to Willis (1952), the skeleton represents one of the most frequent sites of tumor metastasis, surpassed only by the lungs and the liver With regard to the frequency of osseous metastases arising from primary lesions in the breast, Bloodgood (1920) found the breast to predominate over all other sites. Toumey (1943) observed that metastases to the spine in the female most frequently arise from breast neoplasms. Salzman (1954) combined scattered data in the literature and Lahey Clinic material with the incidence of the various cancers in the population and found carcinoma of the breast to be responsible most frequently for skeletal metastases in female patients. Likewise, Abrams (1950), in a projected calculation derived by multiplying the incidence of breast carcinoma per 100,000 general population by the percentage of skeletal metastases resulting from breast cancer in his autopsy series (84%), found the breast to be the most common source of bone metastasis in both the female and the general population.

The incidence of bone metastasis in breast cancer has been reported to occur in varying frequencies. Geschickter and Copeland (1949) observed it in 5 2 per cent of 1,194 cases; however, many of these patients had not reached the 5-year period Willis (1952), on the other hand, states that osseous metastases occur in about one half of fatal cases. Bone lesions from breast neoplasms were found in 42.6 per cent of 162

cases by Warren and Witham (1933), in 81 of 168 cases (48.2%) by Lenz and Freid (1931), and in 57.1 per cent of 105 cases studied by Turner and Jaffe (1940). Willis (1952) points out that the incidence of skeletal metastases cited in fatal cases must necessarily be too small since it is impracticable to examine completely the entire skeleton in routine postmortem work and many metastatic growths are asymptomatic and thereby escape discovery.

Age does not seem to play a significant role in regard to the incidence of bone metastasis from breast carcinoma. The rate of frequency follows the usual curve of incidence of the primary lesion, with no evident deviation toward the younger-age groups (Wulff, 1939; Bouchard, 1945; Rennes, 1952). Wulff found 60 per cent of cases to fall within the age range of 40 to 60, with lower and upper limits of 27 and 78 years. Within this age range Lenz and Fried (1931) reported an incidence of 56 per cent of their cases. Bouchard found the average age of onset of bone metastasis to be 44.4 years, the age varying from 24 to 77 years. Geschickter and Copeland (1949) reported the majority of bone lesions as occurring between the ages of 35 and 55, the extremes in age being 21 and 73. The findings in the present series are in substantial agreement with those cited, and are shown in Table 1. It can be seen that 58.5 per cent of cases of bone metastasis fell within the age range of 40 to 60 years. The average age of patients was 53.1 years, the ages ranging from 33 to 76 years.

CHARACTERISTICS OF THE PRIMARY LESION

There appears to be no significant relationship between the quadrant localization of the primary tumor in the breast and the incidence of subsequent bone metastasis (Bouchard, 1945; Staley, 1956).

Staley conducted an analysis of the clinical characteristics of the primary breast lesion in patients who developed osseous metastases and in those who did not. Fixation of the tumor to the skin was noted in 85 per cent of the former group of patients and in 76 per cent of the latter group. In 80 per cent of the former group the mass was greater than 3 cm., while 68 per cent exhibited such a mass in the latter. Positive axillary nodes were found in 61 per cent and 45 per cent, respectively.

TABLE 1. AGE DISTRIBUTION IN 94 CASES OF CARCINOMA OF THE BREAST WITH METASTASIS TO BONE

AGE RANGE	NO. PATIENTS	PER CENT
21-30...........	1	1.1
31-40...........	17	18.1
41-50...........	23	24.4
51-60...........	32	34.1
61-70...........	15	15.9
71-80...........	6	6.4
	94	100.0

ROUTES OF METASTASIS

Skeletal metastasis from carcinoma of the breast occurs by direct extension to adjacent bone and by lymphatic and blood-stream dissemination to more distant sites. There is controversy as to which of the latter two routes predominates. Handley, in 1922, hypothesized that the skeletal metastases of mammary cancer arose from extensions into the bone from permeation of cancerous cells through the adjacent deep fascial lymphatic plexuses. Carnett and Howell (1930) expressed agreement with this hypothesis, citing the orderly extension of cancer in bones which they observed as being incompatible with any mode of spread other than lymphatic permeation. In addition, the usually mottled appearance of bone which they noted in the earliest stage of invasion of bone anywhere was indicative to them of multiple foci of cancer developing simul-

23

Metastasis to Bone from Carcinoma of the Breast

PAUL D. ZIMSKIND, M.D., AND JAMES M. SURVER, M.D.

Metastatic neoplasms in bone are those malignant tumors which originate outside the skeleton and spread to it by way of the blood stream or the lymphatic channels, or by direct extension (Stein *et al.*, 1955). This chapter attempts to review and add to the body of literature concerning metastases to bone from carcinoma of the female breast, based on a study of patients seen in the Tumor Clinic of the Jefferson Medical College Hospital.

MATERIAL

Ninety-four Tumor Clinic patients with carcinoma of the breast which had produced 199 metastatic lesions in bone were investigated. In 77 of these (81.9%), diagnosis of the primary lesion was made by histopathologic examination; 15 (16.0%) were diagnosed clinically; and in 2 cases (2.1%) the method of diagnosis was not recorded. Various stages in the clinical courses of these patients were noted and subjected to statistic analysis, the results of which will be presented and discussed subsequently.

INCIDENCE

According to Willis (1952), the skeleton represents one of the most frequent sites of tumor metastasis, surpassed only by the lungs and the liver. With regard to the frequency of osseous metastases arising from primary lesions in the breast, Bloodgood (1920) found the breast to predominate over all other sites. Toumey (1943) observed that metastases to the spine in the female most frequently arise from breast neoplasms. Salzman (1954) combined scattered data in the literature and Lahey Clinic material with the incidence of the various cancers in the population and found carcinoma of the breast to be responsible most frequently for skeletal metastases in female patients. Likewise, Abrams (1950), in a projected calculation derived by multiplying the incidence of breast carcinoma per 100,000 general population by the percentage of skeletal metastases resulting from breast cancer in his autopsy series (84%), found the breast to be the most common source of bone metastasis in both the female and the general population.

The incidence of bone metastasis in breast cancer has been reported to occur in varying frequencies. Geschickter and Copeland (1949) observed it in 5.2 per cent of 1,194 cases; however, many of these patients had not reached the 5-year period. Willis (1952), on the other hand, states that osseous metastases occur in about one half of fatal cases. Bone lesions from breast neoplasms were found in 42.6 per cent of 162

cases by Warren and Witham (1933), in 81 of 168 cases (48.2%) by Lenz and Freid (1931), and in 57.1 per cent of 105 cases studied by Turner and Jaffe (1940). Willis (1952) points out that the incidence of skeletal metastases cited in fatal cases must necessarily be too small since it is impracticable to examine completely the entire skeleton in routine postmortem work and many metastatic growths are asymptomatic and thereby escape discovery.

Age does not seem to play a significant role in regard to the incidence of bone metastasis from breast carcinoma. The rate of frequency follows the usual curve of incidence of the primary lesion, with no evident deviation toward the younger-age groups (Wulff, 1939; Bouchard, 1945; Rennes, 1952). Wulff found 60 per cent of cases to fall within the age range of 40 to 60, with lower and upper limits of 27 and 78 years. Within this age range Lenz and Fried (1931) reported an incidence of 56 per cent of their cases. Bouchard found the average age of onset of bone metastasis to be 44.4 years, the age varying from 24 to 77 years. Geschickter and Copeland (1949) reported the majority of bone lesions as occurring between the ages of 35 and 55, the extremes in age being 21 and 73. The findings in the present series are in substantial agreement with those cited, and are shown in Table 1. It can be seen that 58.5 per cent of cases of bone metastasis fell within the age range of 40 to 60 years. The average age of patients was 53.1 years, the ages ranging from 33 to 76 years.

TABLE 1. AGE DISTRIBUTION IN 94 CASES OF CARCINOMA OF THE BREAST WITH METASTASIS TO BONE

AGE RANGE	NO. PATIENTS	PER CENT
21-30...........	1	1.1
31-40...........	17	18.1
41-50...........	23	24.4
51-60...........	32	34.1
61-70...........	15	15.9
71-80...........	6	6.4
	94	100.0

CHARACTERISTICS OF THE PRIMARY LESION

There appears to be no significant relationship between the quadrant localization of the primary tumor in the breast and the incidence of subsequent bone metastasis (Bouchard, 1945; Staley, 1956).

Staley conducted an analysis of the clinical characteristics of the primary breast lesion in patients who developed osseous metastases and in those who did not. Fixation of the tumor to the skin was noted in 85 per cent of the former group of patients and in 76 per cent of the latter group. In 80 per cent of the former group the mass was greater than 3 cm., while 68 per cent exhibited such a mass in the latter. Positive axillary nodes were found in 61 per cent and 45 per cent, respectively.

ROUTES OF METASTASIS

Skeletal metastasis from carcinoma of the breast occurs by direct extension to adjacent bone and by lymphatic and blood-stream dissemination to more distant sites. There is controversy as to which of the latter two routes predominates. Handley, in 1922, hypothesized that the skeletal metastases of mammary cancer arose from extensions into the bone from permeation of cancerous cells through the adjacent deep fascial lymphatic plexuses. Carnett and Howell (1930) expressed agreement with this hypothesis, citing the orderly extension of cancer in bones which they observed as being incompatible with any mode of spread other than lymphatic permeation. In addition, the usually mottled appearance of bone which they noted in the earliest stage of invasion of bone anywhere was indicative to them of multiple foci of cancer developing simul-

taneously from lymphatic permeation. They proposed that invasion of the shoulder girdle was by way of the axilla, cancer cells reaching the axilla either by lymphatic permeation in the breast and along the deep fascia of the chest wall or by lymphatic embolism to the lymph nodes, with secondary permeation beyond them to reach the shoulder girdle. With regard to spread to the lowermost ribs, the lumbar spine, the sacrum and the pelvis, these investigators found malignant deposits in the lymph nodes along the abdominal aorta, the common iliac artery, the internal and the external iliac arteries and, less frequently, along the femoral arteries into the saphenous and the inguinal regions. Since the aortic and the iliac nodes and main channels were seen to lie in close contact with the lumbar spine and the sacrum, and collateral channels extended to the lowermost ribs and the bony pelvis, they felt that permeation probably took place down these channels to give rise to osseous metastases in these sites. In addition, it was their belief that permeation along these intra-abdominal and intrapelvic lymphatics and thence along lymphatics to the ligamentum teres resulted in invasion of the femur. Similarly, Geschickter and Copeland (1949) reported that in cases in which the pelvic bones were involved, not infrequently there was an associated invasion of the head of the femurs, and in some advanced cases they were able to demonstrate direct involvement by means of the ligamentum teres, suggesting an extension of tumor from one bone to another via lymphatics as well as spread from the primary tumor to the regional bones by this route. Nevertheless, these investigators feel that metastasis to bone is primarily via hematogenous routes, as will be indicated. They noted the relative paucity of osseous lesions in the immediate vicinity of the primary tumor in the majority of patients subjected to radical mastectomy early in the course of the disease, suggesting destruction of lymphatics which would have transported neoplastic cells to neighboring bone. On the basis of his frequent discovery of lymph-node involvement in patients who underwent radical mastectomy, Staley (1956) states that the vast majority of cases of carcinoma of the breast which manifest skeletal metastases following radical mastectomy will exhibit pathologic evidence of regional lymphatic involvement at the time of surgical removal of the primary lesion, but he does not feel that his findings warrant the conclusion that skeletal metastases are via lymphatic pathways.

The view that metastasis to bone is hematogenous in nature dates back to 1891, when von Recklinghausen described his hypothesis of the origin of osseous metastases from blood-borne tumor emboli arrested in the sinusoids of the red bone marrow. Several observations favor acceptance of this theory over Handley's lymphatic permeation hypothesis. First of all, lymphatics have not been demonstrated in bone marrow (Willis, 1952), where practically all true metastases are located. Secondly, Warren and Witham (1933) conducted detailed studies in several cases of all tissues intervening between the primary tumor and involved axillary nodes, and found lymphatic permeation to occur in only 1 far-advanced case with widespread metastases. Geschickter and Copeland (1949) and Willis (1952) likewise noted the absence of invasion in the intervening structures between the primary lesion and the metastases to long bones, especially when these metastases were few in number and presumably early. Furthermore, Willis was able to demonstrate coexistent metastases in bones and neighboring lymph glands in only a minority of cases.

The work of Batson (1940) lent considerable credence to the hemic hypothesis of bone metastasis, for by injection of breast venules he was able to demonstrate vertebral vein pathways to the spine, ribs, shoulder girdle and skull. Willis (1952) interprets these findings as a possible explanation of local spread but feels that the usual route of dissemination to more distant bones is via

arterial conduction from tumor deposits in the lungs. Warren and Witham (1933) and Turner and Jaffe (1940) have reported a high incidence of breast-carcinoma metastases existing both in bone and in the lungs. It is reasoned that pulmonary deposits could find easy and direct access to the general circulation and thence to bone.

Direct evidence for the hematogenous route of tumor transport to bone is meager. Worthy of note is Piney's (1922) observation of masses of tumor deposit in bone marrow with outlying plugs in the blood channels at the edge, presumably representing incipient metastases.

DISTRIBUTION OF METASTASES

The great variety of distribution of metastases from various primary sites to bone and other tissues can be accounted for only on the basis of a combination of circumstances (Turner & Jaffe, 1940). Autolysis of a small or a large percentage of cells may occur in transport, cells may fail to survive where they lodge, or cells may remain quiescent in their new locations. The transpulmonary passage of tumor cells undoubtedly is possible, even when foci of neoplasm cannot be demonstrated in the lungs. Also, the filtering power of the lungs, the liver and the regional lymph nodes affects the eventual distribution of metastases. Yet another factor is the predilection of certain primary tumors for certain remote organs, perhaps best explained on the basis of an intrinsic affinity of given neoplastic cells for certain tissue.

Turner and Jaffe (1940) noted a definite correlation of bone metastases with the anatomic distribution of red bone marrow, in that most metastases were found in bones containing the most red marrow. It is felt that the richer vascularity of red bone marrow as compared with yellow marrow is responsible at least in part for the much greater frequency of metastases in the former, but it may also be the case that red marrow is a better soil for the establishment of metastatic deposits (Willis, 1952). Willis suggests that yellow marrow is perhaps no more prone to metastasis than is subcutaneous or perivisceral adipose tissue.

Regarding the distribution of metastatic deposits within a given bone, most often the lesions are multiple (Copeland, 1931; Freid & Goldberg, 1943). Copeland observed single metastases in only one fourth of cases. In the long bones he found the metastatic foci to be located well above the average entrance of the nutrient artery in the case of the femur, and above or below it in the humerus. He was unable to discover a definite relationship between the primary tumor and the homologous bony structure. In 16 cases, half showed a primary lesion with contralateral bone metastases, and the other half demonstrated ipsilateral osseous involvement.

The frequency of involvement of individual bones as reported in the literature is quite variable, and no doubt is due partly to differing degrees of thoroughness in the search for skeletal metastases. Also, studies based on roentgenographic examination alone would tend to demonstrate less extensive distribution of bone lesions than would be seen at autopsy, for deposits in bone may be present without roentgenographic evidence.

Some reports are available on the earliest sites of bone invasion visible roentgenographically. Lenz and Freid (1931) found the lumbosacral spine to be involved first in 39 per cent of cases; the femur, in 18 per cent; the pelvis, in 16 per cent; the skull, in 8 per cent; the thoracic spine, in 7 per cent; the ribs and the scapula, each in 4 per cent; and the humerus, in 2 per cent. Rennes (1952) observed the first localization of bone metastases to be in the form of generalized spread to the spine and the pelvis in 35 per cent. The thoracic spine was the predilection site of the first metastasis in 18 per cent; the pelvis and the sacrum were involved earliest in 14 per cent; the ribs or the sternum, in 11 per cent; the lumbar spine,

TABLE 2. DISTRIBUTION OF 199 BONE METASTASES IN 94 CASES OF CARCINOMA OF THE BREAST

	No. Metastases	Percentage of Total Metastases
Lumbar vertebrae ..	39	19.6
Ribs	29	14.6
Pelvis	28	14.1
Thoracic vertebrae ..	26	13.1
Skull	24	12.1
Femur	22	11.0
Humerus	11	5.5
Scapula	8	4.0
Clavicle	4	2.0
Cervical vertebrae ..	3	1.5
Sternum	2	1.0
Tibia	2	1.0
Radius	1	0.5
	199	100.0

in 6 per cent; the cervical spine, in 5 per cent; the femur, in 4 per cent; and the shoulder girdle, in 3 per cent. These findings are at variance with those of Carnett and Howell (1930), who reported the order of frequency of early bone invasion, excluding instances of direct extension to ribs underlying the breast lesion, as being the homolateral shoulder girdle, the third to the sixth thoracic vertebrae, the upper lumbar vertebrae, the pelvic bones and the lower cervical vertebrae. Thus, these investigators disagreed with the commonly expressed statement in the literature that metastases to the clavicle and the scapula were relatively rare findings in breast cancer. However, Geschickter and Copeland (1949) ascribe this high incidence of shoulder-girdle metastasis to the fact that radical mastectomies were rare in the cases studied by these workers; therefore, adjacent lymphatic drainage was intact.

TABLE 3. SITES OF BONE METASTASES IN PATIENTS WITH CARCINOMA OF THE BREAST

	Tumor Clinic	Staley	Bouchard	Freid	Dresser	Paletta	Geschickter	Carnett
No. of cases ..	94 %	166 %	24 %	81 %	134 %	48 %	100 %	101 %
Lumbar vertebrae ..	41.5	53.0	71 0	34	50	52	—	43.5
Ribs	30 8	61.4	71.0	39	31	30	13	34 6
Pelvis . ..	29.8	59.6	75.0	62	64	40	29	44.5
Thoracic vertebrae .	27 6	39.1	62.5	24	40	—	—	40.5
Skull	25.5	34 9	25 0	35	44	—	13	13.8
Femur	23.4	46 4	54.0	54	—	—	22	31.6
Humerus	11 7	10.9	12.5	27	—	—	6	—
Scapula	8.5	9.6	25.0	16	—	—	3	—
Clavicle	4.3	9.0	8.3	14	—	—	3	—
Cervical vertebrae ..	3 2	7 2	33 0	8	17	—	—	10 1
Sternum	2.1	10.9	8.3	1	—	—	4	—
Tibia	2.1	—	—	3	—	—	1	6 9
Radius	1.1	—	—	1	—	—	1	5.7

Bouchard (1945) states that there seems to be a close parallel between the order of time and the rate of incidence in which the same bones are involved. This observation is borne out for the most part by comparing the early sites of metastases cited above with reports of the over-all incidence of osseous lesions from the breast in the literature and with the incidence of these lesions encountered in the present study. Table 2 depicts the distribution in various bones of the 199 metastatic deposits seen in the 94 patients in this series. The cervical, the thoracic and the lumbar vertebrae considered together account for 34.2 per cent of the osseous metastases. Table 3 shows the percentage of Tumor Clinic patients afflicted with metastases to certain bones and related findings in other studies. The cumulative percentage distribution of the more common bone lesions from breast cancer is found in Table 4. The percentages were arrived at by multiplying the total number of cases in each series by the percentage incidence of metastasis for each site in order to determine the actual number of cases of metastasis to a given site in the different series. The sum of these figures then was applied to the sum of the total number of patients in all the series, 748 in all, in which metastases to the given sites were included to produce the percentage relationships shown. There is considerable variation in the order of frequency of affected sites in the different studies, for reasons mentioned earlier. Most likely the order shown in Table 4 is closest to the true incidence.

TABLE 4. CUMULATIVE PERCENTAGE DISTRIBUTION OF BONE METASTASES IN PATIENTS WITH CARCINOMA OF THE BREAST, BASED ON DATA IN TABLE 3 (748 CASES)

SITE	PER CENT OF CASES
Pelvis	50.0
Lumbar vertebrae	47.4
Ribs	38.1
Femur	37.2
Thoracic vertebrae	35.6
Skull	28.8
Humerus	12.8

PATHOLOGIC FEATURES OF BONE METASTASIS

The inception of metastases from carcinoma of the breast seems to be in the marrow in most cases, as mentioned earlier.

Grossly, the medullary cavity becomes replaced by grayish tumor tissue, and the cortex of the bone on each side of the tumor mass is thinned. The neoplasm is soft and compressible, and usually is well demarcated in the long bones and less well circumscribed in the pelvis.

Histologically, the microscopic appearance of the tumor cells in bone generally resembles closely that of the primary lesion in the breast (Willis, 1952). According to Milch and Changus (1956), the histologic appearance in the host bone of "osteolytic" and "osteoblastic" lesions is qualitatively identical, the difference being a quantitative one dependent on the amount of bone destruction relative to the amount of bone proliferation present at a given moment.

The mechanism of bone destruction is said to involve (1) direct mechanical pressure exerted by the tumor cells and/or (2) a physiochemical process occurring at the bone surface which is somehow promoted by the neoplastic cell in destroying the normal continuous layer of cells covering the surfaces of the bone crystals. Sharpe and McDonald (1942) have consistently observed the apparent destruction of both spongy and cortical bone by direct contact of the tumor cells with the bone. Noting that tumor cells alone were very frequently the center of destruction in bone lesions, they concluded that these cells acted in the capacity of osteoclasts.

Bone production represents an attempt by the host bone to repair the injury effected by cancer invasion (Milch & Changus, 1956). There is no evidence to suggest that this

particular repair phenomenon is caused by *any abnormal substance.*

The pathogenetic factors relating to whether the osteolytic or the osteoblastic form of metastasis will predominate are unknown. The process may be a function of the rate at which the metastasis grows (Wulff, 1939; Bouchard, 1945). Presumably, when growth is rapid, little new bone formation can occur and the lesion will be predominantly osteolytic. If growth is slow, *the possibilities for defense are increased,* and bone formation will produce a chiefly osteoblastic type of metastasis. Copeland (1931) has observed in this regard the direct transition of bone fibroblasts to osteoblasts to bone tissue in the presence of invading metastatic tumor cells. Other explanations attribute the predominant type of reaction seen to the grade of the lesion and the phosphatase content of the metastatic tissue (Staley, 1956).

Once metastasis is established in a bone, further spread takes place along the medullary cavity and the Volkmann and the haversian canals (Milch & Changus, 1956).

ALTERATIONS IN BLOOD AND URINE

In most cases of early metastases to bone, the blood picture is normal With advancement of the neoplastic process a macrocytic anemia may be encountered, as well as an increased sedimentation rate (Turner & Jaffe, 1940; Geschickter & Copeland, 1949). Occasionally a trace of albumin is found in the urine, and in 3 of 100 cases of metastasis to bone from breast cancer Geschickter and Copeland (1949) isolated Bence-Jones protein.

The reactions in bone to tumor invasion described earlier play a role in producing changes in blood and urine chemistry. If bone destruction exceeds bone production, calcium is lost and the change is reflected in an increased excretion of calcium in the urine and the feces. When the osteoblastic reaction predominates, urinary calcium excretion generally is lower than normal (Baker, 1956). Laszlo and his colleagues (1952) describe the metabolic picture of marked osteolysis as being characterized by a negative calcium and phosphorus balance, with the excessive urinary calcium excretion noted above and hyperphosphaturia. With the progression of the osteolysis and negative mineral balance to excessive degrees, hypercalcemia becomes manifest. These investigators envision the sequence of events leading to hypercalcemia as (1) excessive breakdown of bone; (2) mobilization of calcium and phosphorus; (3) hypercalciuria and hyperphosphaturia; and (4) hypercalcemia. Prolonged hypercalciuria and hypercalcemia then produce (5) renal impairment, which thus is a secondary phenomenon. In cases of impending hypercalcemia, Myers *et al.* (1956) report that urinary calcium studies are of value in the early recognition of the condition.

The difference in calcium balance or in urinary calcium excretion between a normal person and a patient with osteolytic involvement is readily measurable. Accordingly, calcium-excretion studies afford an objective index of the rate of bone destruction in patients with metastatic lesions and thereby provide a method for evaluating changes in the rate of tumor growth in many patients with carcinoma of the breast which has reached bone.

Fluctuations in the relative amount of osteolysis and osteoplasia occurring in patients with metastatic bone disease have been observed to produce corresponding changes in the serum alkaline phosphatase level. The serum level of this enzyme is elevated during bone repair and exhibits normal or lowered values when bone destruction is predominant (Laszlo *et al.*, 1952; Griboff *et al.*, 1954). The former group has provided evidence suggesting that a premonitory fall in serum alkaline phosphatase activity precedes the onset of hypercalcemia. Griboff and his co-workers observed that in 92 per cent of

patients with hypercalcemia secondary to osseous metastases from breast cancer, a change in the serum-calcium level was related inversely to a change in alkaline phosphatase activity.

Kaufman *et al.* (1955) have noted the presence of higher levels of beta-lipoproteins in the plasma of patients with carcinoma of the breast and skeletal metastases than in patients with advanced breast cancer and no osseous involvement. The significance of this finding is not fully comprehended at the present time.

CLINICAL ASPECTS OF BONE METASTASIS

The history elicited from patients with osseous metastases from carcinoma of the breast may be quite vague, and diagnosis in the early stages of spread may be difficult indeed. Oppenheimer (1922) explains the difficulty in diagnosis as being due to the dearth of definite objective symptoms that obtains so long as the metastatic deposit remains confined within the substance of the bone. Bone lesions of considerable size may fail to produce pain, as Salzman (1954) has observed. Geschickter and Copeland (1949) set the duration of symptoms of bone metastases in general prior to diagnosis as being in excess of 1 year.

Pain usually is the first symptom of tumor invasion of the skeletal system. Freid and Goldberg (1943) found that in 75 per cent of 81 cases, attention was focused on the presence of bone metastases because of the complaint of localized pain. This pain usually was at the site of the malignant focus, although occasionally it was located over the distribution of the adjacent nerve. Pain seems to appear earliest and to be most severe where the natural weight of the body and muscular traction are more pronounced (Lenz & Freid, 1931; Bouchard, 1945). Thus, pain due to metastatic involvement of the lumbar spine or the sacral region usually is present early, while metastasis to the skull does not commonly produce pain until late, when it has attained considerable size or is causing increased intracranial pressure. As will become evident, the outstanding complications of bone metastasis are (1) severe pain, (2) pathologic fracture and (3) compression of important neurologic structures (Geschickter & Copeland, 1949).

The symptomatology produced by metastases to individual bones will now be considered. In the case of spread to vertebrae, symptoms are absent so long as the tumor deposits remain within the bone; it is when the process begins to emerge and invade the extramedullary tissues that symptoms appear. Also, the tumor may undermine the bodies of the vertebrae, causing them to collapse, and the resultant change in contour may then produce symptoms (Oppenheimer, 1922). The condition often is completely unsuspected in the early stages. Vague back pains and a negative roentgenographic report may suggest a functional disorder. In the late stages of vertebral metastasis, the symptoms usually are definite and reflect extramedullary impingement upon the spine or the spinal roots. Pain is an important symptom, and may be described as sharp, boring, tearing and/or lancinating. It is distributed along the course of a spinal root or roots. In the case of cervical metastases, there frequently is pain in the back of the neck, the shoulder or the arm. With thoracic neoplasms, pain is in the back, the shoulders, under the scapula, in the kidney area or beneath the rib cage. With lumbar tumors there is pain in the back or the leg along the distribution of the sciatic nerve or along the course of other nerve roots in the leg (Alpers, 1954). There may also be associated paresthesias. Motor weakness and sensory disturbances may occur, usually as later symptoms.

The incidence of various symptoms produced by metastases to individual sites in the present series is shown below.

The findings in the vertebrae were as follows: of the 3 patients with metastasis to the cervical vertebrae, all (100%) experienced local pain over the involved bones, and root pain was present in 1 (33.3%). In 26 cases of thoracic tumors, back pain was a complaint in 16 (61.5%), and root pain was evident in 1 case (3.9%). Lumbar metastases produced low back pain in 25 of 39 patients (64.2%) and sciatica in 9 (23.2%).

In 29 cases of rib involvement, 11 developed pathologic fractures (37.9%) and 9 experienced local pain (31%). The subject of pathologic fractures in bone metastasis will be considered subsequently.

With regard to neoplastic growth in the pelvis, 28 metastatic lesions produced sciatica in 6 (21.4%), local pain over involved areas in 3 (10.7%) and pathologic fracture and low back pain in 1 (3.6%) each.

Involvement of the skull in 24 instances resulted in headache in 4 cases (16.7%), local swelling in 3 (12.5%) and local pain in 1 (4.2%).

Metastases to the femur in 22 cases led to pathologic fracture in 11 instances (50%) and to local pain in 5 (22.8%).

In 11 cases of metastasis to the humerus, pathologic fracture occurred in 3 (27.3%); local pain was present in the same number.

Metastases to the clavicle in 4 cases were followed by local pain in 1 instance and by pain in the arm in another (25% each).

Tumor deposition in the sternum in 2 cases produced local pain in both (100%) and swelling in 1 (50%).

Local pain was present in 1 of 8 cases of metastasis to the scapula (12.5%). No other symptoms were noted.

The principal finding on physical examination of patients with osseous metastases is the presence of bone tenderness on direct pressure or percussion (Freid & Goldberg, 1943; Bouchard, 1945). In addition, Oppenheimer (1922) advocates diagnostic palpation of the spinous processes for recessions that occur with the deformation of the spine in extensive cancer invasion.

ROENTGENOGRAPHIC FINDINGS

The observation cited previously that clinical symptomatology may precede roentgenologic evidence of metastatic lesions in bone has been widely shared (Oppenheimer, 1922; Freid & Goldberg, 1943; Bouchard, 1945). Copeland (1931) noted that occasionally pain preceded the roentgenographic demonstrability of bone metastases from breast cancer by from 3 to 18 months Nevertheless, the merit of the routine skeletal survey in detecting skeletal metastases in patients with carcinoma of the breast remains. The importance of such surveys is emphasized by the work of Staley (1956), who employed an abbreviated survey consisting of roentgenograms of only the lumbar spine, the pelvis, including the upper femora, and the chest, showing the ribs, and was able to demonstrate bone metastases in 90 per cent of patients with known osseous involvement from carcinoma of the breast Hyman and Harvey (1955) have combined skeletal roentgenologic survey with bone-marrow aspiration in their evaluation of patients with metastatic carcinoma. They report that frequently marrow aspiration provided the only proof of the existence of metastasis when other survey methods, including roentgenographic examinations, were negative.

The roentgenographic appearance of metastatic lesions from breast cancer is correlated with the reactions which are operative. An increased rate of tumor growth with a correspondingly increased rate of bone destruction produces a lesion seen on roentgenogram as "osteolytic." In instances in which the rate of bone repair is greater than the rate of destruction, the lesion appears roentgenographically to be "blastic" (*Milch & Changus, 1956*). There is almost no periosteal reaction (Geschickter & Copeland, 1949).

Collapse of a vertebral body occasionally is the first evidence of a metastatic involvement, although the trabecular pattern of the narrowed body may be maintained (Bachman, 1956).

The incidence of osteolytic, osteoblastic and mixed lesions seen on roentgenogram was determined in the present series of 199 bone metastases from breast cancer. Lytic deposits were found in 176 cases (88.5%), blastic lesions in 7 (3.5%), and a mixture was observed in 16 (8.0%). These findings are in general agreement with previous reports in the literature (Carnett & Howell, 1930; Lenz & Freid, 1931; Sharpe & McDonald, 1942; Paletta & Lehman, 1944; Bouchard, 1945; Staley, 1956).

PATHOLOGIC FRACTURES

According to Codman (1922), a pathologic fracture implies a trivial force acting on abnormal bone. Walking, running, coughing, rising or sitting down, and even turning over in bed have been implicated as secondary causes. Aside from the trivial cause involved, pathologic fractures differ from the usual fractures in other respects. Codman describes them as being more likely in the form of bendings, bowings, bucklings, telescopings and impactions. Usually the ends do not tend to separate widely or slip by one another. Still, they are not "greenstick" fractures; "rotten wood" fractures more properly describes them.

The incidence of pathologic fracture in patients having bone metastases from carcinoma of the breast has been reported variously to range from 15 per cent to 48 per cent (Copeland, 1931; Lenz & Freid, 1931; Bouchard, 1945; Staley, 1956). Among the 94 Tumor Clinic patients with metastatic disease, pathologic fractures were present in 26 (27.6%). The ribs and the femur were each the site of fracture in 11 of the 26 patients (42.3% each), the humerus was involved 3 times (11.5%), and the pelvis in 1 case (3.9%). The incidence of pathologic fractures with respect to the number of metastases at given sites has been presented above. Although studies in the literature are small, the femur and the ribs are commonly noted sites of pathologic fracture in comparison with other bones. There is considerable variation in the reported incidence of pathologic fractures in the humerus (Copeland, 1931; Lenz & Freid, 1931; Willis, 1952; Staley, 1956), exactly as there is variation in the reported frequency of metastases to this site, as mentioned above. Eliason and Wright (1930) explain the relatively high incidence of pathologic fractures in the long bones as compared with flat bones as being the result of the direct and the indirect forces, including weight-bearing, torsion and muscle play, which are exerted upon the long bones. Flat bones, on the other hand, seldom are traumatized, except by direct force. Thus pathologic fractures of the skull or the ilium seldom are seen.

Perusal of the methods employed in diagnosing the 26 pathologic fractures seen in the present series furnished the interesting observation that the lesions were diagnosed first by roentgenographic studies in 7 cases Thus, in 26.9 per cent of cases skeletal fractures were present but clinically silent. Clinical symptoms and signs provided the initial diagnosis in the remaining 19 cases (73.1%).

TIME RELATIONSHIPS IN BONE METASTASIS

Time relationships of certain stages of the disease in patients with carcinoma of the breast with bone metastases were studied in an attempt to contribute to an understanding of the process.

Interval Between Recognition of Primary Tumor and Bone Metastasis

Before considering the time interval between the recognition of the breast tumor and the subsequent development of bone metastases, it is necessary to recognize that certain difficulties are present. First of all,

the actual onset of the tumor cannot be ascertained; therefore, it is impossible to calculate the duration of its presence. Secondly, the precise time at which the neoplasm reaches bone cannot be judged, for methods of detection of skeletal metastases are as yet insensitive to the early foci. The variable time of appearance of clinical and roentgenologic manifestations of the same lesion in bone has been mentioned.

Despite these uncertain factors, reports in the literature do not differ significantly from findings in the present study. Bouchard (1945) found a gross mean interval of 45.3 months between the known onset of the primary growth and the roentgenographic evidence of skeletal metastases. By excluding two exceptionally long cases (9- & 17-year intervals) he arrived at a net mean interval of 34.0 months. The interval varied from 3 months to 17 years. Geschickter and Copeland (1949) reported a gross mean interval of 32.5 months in patients subjected to radical mastectomy and a net value (omitting a few exceptional cases with intervals as late as from 9 to 20 years) of 30 months. In the records of 46 of the 94 patients in the Tumor Clinic series, including cases too far advanced for attempts at "cure," it was possible to ascertain both the time at which the breast lesion was noted and the onset of osseous metastases as first indicated either by clinical or roentgenologic evidence. The gross mean interval between these occurrences was 39.8 months. By excluding 4 cases in which the intervals ranged from 9.3 to 12.5 years, a net average of 32.0 months was obtained The shortest interval was 3 months; the longest, 12.5 years.

Interval Between Treatment of the Primary Lesion and Bone Metastasis

The interval between the time of treatment of the primary breast lesion and the onset of bone metastases was reported by Sharpe and McDonald (1942) to average 15 months; by Staley (1956), 19.8 months; and by Copeland (1931) and Toumey (1943), 30 months. In exceptional instances, itnervals as long as 20 years occurred. In most cases initial treatment was in the form of radical mastectomy with or without radiation therapy. Fifty-six Tumor Clinic patients were studied, 59 per cent having been subjected to radical mastectomy and 41 per cent to radical mastectomy and roentgenotherapy. The average interval before the appearance of skeletal metastases, diagnosed clinically and/or roentgenographically, was somewhat longer than those cited, being 40 months in duration. The cumulative percentage of cases developing osseous metastases within certain time intervals, as found in this and other studies, is shown in Table 5.

Table 5. Interval Between Treatment of the Primary Lesion and Metastasis to Bone

	Tumor Clinic	Paletta	Staley
No. Cases	56	25	55
Interval (Months)	Cumulative Per Cent	Cumulative Per Cent	Cumulative Per Cent
0-6	11	20	24
7-12	18	40	44
13-18	25	—	58
19-24	43	60	71
25-36	63	76	80
37-48	71	80	93
49-60	80	88	96
60 + ...	100	100	100

Duration of Disease and Number of Bone Metastases per Patient

An attempt was made to discover whether or not the length of time that breast cancer existed in a patient played a role in the number of bone metastases that developed. Accordingly, patients were selected for whom data were available concerning the interval between the time of known onset of the primary breast lesion and death, this interval representing the duration of the

TABLE 6. NUMBER OF INDIVIDUALS WITH 1, 2 AND 3 OR MORE BONE METASTASES FROM CARCINOMA OF THE BREAST AT VARIOUS DURATIONS OF DISEASE

Duration of Disease (Months)	No. of Bone Metastases Per Patient			
	1	2	3 or more	Total
0-36	5	6	8	19
37-65	6	6	7	19
66+	5	10	5	20
Total	16	22	20	58

disease. These data were available in 58 patients. In this group, those having a given number of metastases were arranged according to the length of time they were known to have had malignant disease, as shown in Table 6. To provide as equal a distribution as possible, the periods of duration were divided into the 3 groups shown; likewise, classifying patients according to the presence of 1, 2 and 3 or more bone lesions gave a subdivision into thirds. The chi-square test was used to see whether or not there was any significant association between the duration and the number of metastases Chi-square equaled 5.78, which with 4° of freedom gave a probability greater than 0.2. Hence, there was no evidence of any relationship between the duration of disease and the number of metastases that developed (Menduke, 1957). The significance of this finding will be discussed subsequently.

DISCUSSION

The general agreement of findings in this study with other reports regarding the age incidence of bone metastases, distribution, proportionate types of bone lesions seen, incidence of pathologic fractures and the interval between the onset of the primary lesion and bone metastasis has been noted.

Certain other features are worthy of amplification. The observation that 26.9 per cent of the cases of pathologic fracture encountered in this series were clinically silent and were first noted on roentgenographic examination emphasizes the importance of periodic skeletal survey in the management of patients with metastatic disease. Realization of the presence of such lesions would lead to the institution of palliative measures aimed at preventing or at least diminishing ill effects from subsequent trauma to the involved areas.

It will be noted that considerable variation exists in the average intervals between the treatment of the primary breast lesions and the development of subsequent osseous metastases reported in this study and in the others cited, the intervals being much longer in the latter. A possible explanation of this discrepancy is afforded by reference to Table 5, which indicates that the most pronounced differences between the Tumor Clinic findings and the others occurred relatively early in the course of the disease. Higher percentages of metastases were noted here in the other studies than in the present series. It is suggested that in the reports of Paletta and Lehman (1944) and Staley (1956), more bone lesions were present and unrecognized at the time of initial treatment than in the Tumor Clinic series.

The lack of relationship between the duration of malignant disease and the number of bone metastases that occur is at first surprising, since it might be expected that a primary lesion present for a long period of time would tend to give rise to more metastases than one present only briefly. It may be speculated, however, that there are present in this series 2 distinct groups of patients, one with a highly malignant type of lesion which produced metastases relatively rapidly, as well as early death, and another having a tumor of less malignant nature. The latter variety would give rise to less metastases early, but in the longer duration of time the patient could survive with the disease equivalent dissemination could occur. Correlation of these findings with the histopathologic grading of the lesions was not carried out,

but such a study undoubtedly would contribute to the understanding of the natural history of carcinoma.

SUMMARY

1. In Tumor Clinic patients with carcinoma of the breast with metastasis to bone, 58.5 per cent were between 40 and 60 years of age. The average age was 53.1 years.

2. Reports in the literature concerning the characteristics of the primary lesion were cited.

3. Concepts of the routes of metastasis to bone were considered. The theory of hematogenous spread is favored by most at the present time.

4. The bones affected most frequently in this series were the lumbar vertebrae, ribs, pelvis, thoracic vertebrae, skull, femur and humerus. The order of frequency calculated from accumulated studies ranked the pelvis, lumbar vertebrae, ribs, femur, thoracic vertebrae, skull and humerus.

5. Mechanisms of bone reaction to metastases were described. The process appears to be one of bone destruction followed by varying degrees of bone repair.

6. Changes occurring in the blood and urine levels of calcium and phosphorus, as well as in the serum alkaline phosphatase and plasma beta-lipoproteins, reflect the presence and the activity of bone metastases.

7. Clinical features of bone metastases were classified according to various sites. Pain was the symptom noticed most commonly.

8. Roentgenographic evidence of metastases to bone usually appears later than do symptoms, according to most reports. In this study the lesions were osteolytic in 88.5 per cent, osteoblastic in 3.5 per cent, and mixed in 8 per cent.

9. Pathologic fractures occurred most commonly in the ribs and the femur; the humerus and the pelvis were infrequent sites. In 26.9 per cent of cases the lesions were first detected roentgenographically, suggesting the necessity for periodic skeletal surveys in patients with metastatic disease.

10. The net mean interval between the time of known onset of the primary lesion and the appearance of bone metastases in cases treated "curatively" as well as cases treated palliatively was 32 months.

11. The average interval between initial "curative" treatment of the breast lesion and the development of metastases to bone was 40 months.

12. The duration of malignant disease was not related to the number of bone metastases per patient that appeared. It is hypothesized that patients with rapidly fatal metastatic disease develop as many metastases quickly as do patients with less fulminating disease over longer periods of time.

BIBLIOGRAPHY

Abrams, H. L.: Skeletal metastases in carcinoma, Radiology 55:534-538, 1950.

Alpers, B. J.: Clinical Neurology, Philadelphia, Davis, 1954.

Bachman, A. L.: The radiographic appearance of metastatic bone disease, New York J. Med. 56:3647-3654, 1956.

Baker, W. H.: Abnormalities in calcium metabolism in malignancy; effects of hormone therapy, Am. J. Med. 21:714-720, 1956.

Batson, O. V.: The function of the vertebral veins and their role in the spread of metastases, Ann. Surg. 112:138-149, 1940.

Bloodgood, J. C.: Bone tumors, benign and malignant: a brief summary of the salient features based upon a study of some 370 cases, Am. J. Surg. 34:229-237, 1920.

Bouchard, J.: Skeletal metastases in breast cancer; study of the character, incidence and response to roentgen therapy, Am. J. Roentgenol. 54:156-171, 1945.

Carnett, J. B., and Howell, J. C.: Bone metastases in cancer of the breast, Ann. Surg. 91:811-832, 1930.

——— Bone metastases in cancer of the breast, a comparative clinical and pathological study of tumors metastasizing to bone and to viscera, Surgery 15:944-953, 1944.

Codman, E. A.: Pathological fractures, Surg., Gynec. & Obst. 34:611-613, 1922.

Copeland, M. M.: Bone metastases, Radiology 16:198-210, 1931.
Dresser, R., and Pelletier, V. A.: The radiological management of cancer of the breast, New England J. Med. 214:720-723, 1936.
Eliason, E. L., and Wright, V. W. M.: Pathological fractures, S. Clin. North America 10:1335-1376, 1930.
Freid, J. R., and Goldberg, H.: Frequency, clinical course and treatment of metastases from cancer of the breast, Am. J. Roentgenol. 50:499-511, 1943.
Geschickter, C. F., and Copeland, M. M.: Tumors of Bone, Philadelphia, Lippincott, 1949.
Griboff, S. I., Herrmann, J. B., Smelin, A., and Moss, J.: Hypercalcemia secondary to bone metastases from carcinoma of the breast. I. Relationship between serum calcium and alkaline phosphatase values. J. Clin. Endocrinol. 14:378-388, 1954.
Handley, W. S.: Cancer of the Breast and Its Treatment, New York, Hoeber, 1922.
Hyman, G. A., and Harvey, J. L.: A comparison of bone-marrow aspiration and skeletal roentgenograms in the diagnosis of metastatic carcinoma, Cancer 8:576-581, 1955.
Kaufman, R. J., Barclay, M., Kidder, E. D., Escher, G. C., and Petermann, M. L.: Human plasma lipoproteins. II. The effect of osseous metastases in patients with advanced carcinoma of the breast. Cancer 8:888-889, 1955.
Laszlo, D., Schulman, C. A , Bellin, J., Gottesman, E. D., and Schilling, A.: Mineral and protein metabolism in osteolytic metastases, J.A M A. 148:1027-1032, 1952
Lenz, M., and Freid, J. R.: Metastases to the skeleton, brain and spinal cord from cancer of the breast and effect of radiotherapy, Ann. Surg 93:278-293, 1931.
Menduke, H . Personal communication, 1957.
Milch, R. A., and Changus, G. W : Response of bone to tumor invasion, Cancer 9:340-351, 1956
Myers, W. P. L , West, C. D., Pearson, O. H., and Karnofsky, D. A : Androgen-induced exacerbation of breast cancer measured by calcium excretion, conversion of androgen to estrogen as a possible underlying mechanism, J A.M A 161:127-131, 1956.
Oppenheimer, E. D.: Early symptoms of spinal cancer, J. Bone & Joint Surg. 20:342-356, 1922.
Paletta, F. X., and Lehman, E. P.: Carcinoma of the breast; a comparative clinical and pathological study of tumors metastasizing to bone and to viscera, Surgery 15:944-953, 1944.
Piney, A.: Metastases in bone marrow, J. Path. & Bact. 25:140-142, 1922.
Recklinghausen, von, F. D.: Die fibröse oder deformirende Ostitis, die Osteomalacie and die osteoplastische Carcinose in ihren gegenseitigen Beziehung, *in* Festschrift Rudolf Virchow zu seinem 71. Geburtstage gewidmet, pp. 1-89, Pl. 1-5, Berlin, 1891. Cited by Willis (1952) and Baker (1956).
Rennes, S.: Carcinoma of the breast and skeletal metastasis in a clinico-roentgenologic series, Acta. chir. scandinav. 103:363-369, 1952.
Salzman, F. A.: Patterns of metastatic bone disease and their implications, S. Clin. North America 34:859-863, 1954.
Sharpe, W. S., and McDonald, J. R.: Reaction of bone to metastasis from carcinoma of the breast and the prostate, Arch. Path., Chic. 33:312-325, 1942.
Staley, C. J.: Skeletal metastases in cancer of the breast, Surg., Gynec. & Obst. 102:683-688, 1956.
Stein, I., Stein, R. O., and Beller, M. L.: Living Bone in Health and Disease, Philadelphia, Lippincott, 1955.
Toumey, J. W.: Metastatic malignancy of the spine, J. Bone & Joint Surg. 25:292-305, 1943.
Turner, J. W., and Jaffe, H. L.: Metastatic neoplasms: clinical and roentgenological study of involvement of skeleton and lungs, Am J. Roentgenol. 43:479-492, 1940.
Warren, S , and Witham, E. M.: Studies on tumor metastasis. 2. The distribution of metastases in cancer of the breast. Surg., Gynec. & Obst. 57:81-85, 1933.
Willis, R. A.: The Spread of Tumours in the Human Body, ed. 2, London, Butterworth, 1952
Wulff, H. B.: Radiological treatment of skeletal metastases in mammary cancer, Acta radiol. 20:40-68, 1939.

Metastase a Osso ab Carcinoma Mammari

Summario in Interlingua

Novanta-quatro patientes con carcinomas mammari, que habeva resultate in 199 lesiones metastatic in osso, esseva studiate al Clinica pro Tumores affiliate con le Hospital del Collegio Medical Jefferson. Le etate medie del patientes esseva 53,1 annos, e 58,5 pro cento del patientes habeva inter 40 e 60 annos de etate. Le ossos afficite le plus frequentemente esseva le vertebras lumbar, le costas, le pelve, le vertebras thoracic, le cranio, le femore, e le humero. Le analyse del presente investigation e de comparabile studios per altere autores permitte calcular le sequente ordine de frequentia del varie affectiones: Pelvic, lumbo-vertebral, costal, femoral, thoraco-vertebral, cranial, e humeral. Le plus marcate symptoma de metastase ossee esseva dolores, de natura variabile secundo le sito del lesion. Manifestationes roentgenographic del metastase al osso appareva usualmente plus tarde que le symptomas. Secundo le evidentia roentgenographic, 88,5 pro cento del lesiones esseva osteolytic, 3,5 pro cento osteoblastic, e 8 pro cento miscite. Fracturas pathologic post metastases ossee occurreva le plus communmente in le costas e le femore. Le fracturas esseva primo discoperite per medio de radios X in 26,9 pro cento del casos. In iste casos, nulle symptomas habeva essite notate. Le intervallo medie inter le tempore del declaration del lesion primari e le tempore del apparition del metastase ossee in casos tractate como "curabile" e etiam in casos sub tractamento palliative esseva 32 menses (post excluder alicun casos exceptional). Le intervallo medie inter le initiation de essayos de therapia curative attaccante primari lesiones mammari e le disveloppamento de metastases ossee esseva 40 menses. Le duration del morbo maligne non esseva relationate al numero de metastases ossee que appareva in le patientes individual. Es proponite le formula que patientes con formas rapidemente mortal del morbo disveloppa rapidemente le mesme numero de metastases como patientes con minus fulminante formas del morbo lo face in le curso de plus longe periodos de tempore.

Section III

ITEMS

24

Reconstruction of the Extensor Mechanism of Two Fingers in a Congenital Deformity*

A Case Report

JOSÉ DIAZ HUMARA, M.D., AND LUIS IGLESIAS, M.D.†

We present an interesting and unusual case of a congenital deformity of the finger caused by an abnormal laxity of the lateral bands or slips of the extensor mechanism of the finger.

We must remember from the anatomy that the tendons on the back of the hand are flattened, forming membranous expansions over the metacarpal heads. These membranous expansions are known as the dorsal aponeuroses of the finger (Fig. 1 A). As is known, the lateral borders of these dorsal aponeuroses receive the insertions of the interossei and the lumbricales. The central portion of the tendon inserts into the proximal end of the second, or middle, phalanx after it crosses the dorsum of the proximal phalanx. The lateral slips pass round the sides of the back of the proximal interphalangeal joint and reunite over the distal interphalangeal joint (Fig. 1 B). The common extensor tendons and the intrinsic muscles working at the same time can flex, extend or spread the fingers. This is due to the displacement of the aponeurosis, which occurs when the extensor tendon is tense or relaxed. When the extensor tendon is placed under tension, the whole finger can be extended completely due to its lateral slips, and at the same time the interossei can realize the abduction or the adduction of the finger.[1-5]

In our case there was a congenital anomaly of the lateral bands or slips, which were displaced dorsally. The proximal interphalangeal joint was in hyperextension and the patient was unable to extend the distal interphalangeal joint fully (Figs. 1 C & 2, *left*). The most interesting aspect of this case was that during the operation under local anesthesia and at the very moment of returning the bands to their normal position, the deformity was corrected immediately and dramatically (Fig. 1 D).

M. R., a 19-year-old white male, presented a congenital anomaly of the dorsal bands of the extensor mechanism of the fingers with an exaggerated laxity in them, so that they were displaced dorsally to the axis of the fingers and the patient was unable to extend the distal phalanx. The result was the deformity here described consisting of a hyperextension of the proximal interphalangeal joint and the impossibility of total extension of the distal phalanx

* Read at the ninth annual meeting of the Association of Bone & Joint Surgeons, Havana, Cuba, April 4, 1957

† From the Hospital Nacional de la Organización Nacional para la Rehabilitación de Inválidos (O.N.R.I.), Havana, Cuba.

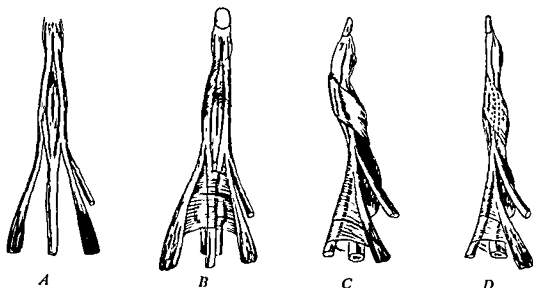


Fig. 1. (Reading from left) (A) Represents part of the extensor mechanism of the finger. The interosseous muscles and their *insertions into the lateral* bands are shown. Note the membranous expansions known as the dorsal aponeuroses of the finger. (B) The central portion of the tendon is inserted into the proximal end of the second, or the middle, phalanx. The lateral slips pass round the sides of the back of the proximal interphalangeal joint, becoming reunited over the distal interphalangeal joint. Observe the insertion of the interosseous and the lumbricales into the lateral bands. (C) Represents the anomaly. The lateral bands are displaced dorsally, being unable to extend completely the distal phalanx and hyperextending the proximal joint. (D) The dotted lines represent the corrected position of the bands toward the axis of the finger When the bands were placed in this position, the deformity was corrected immediately and dramatically.

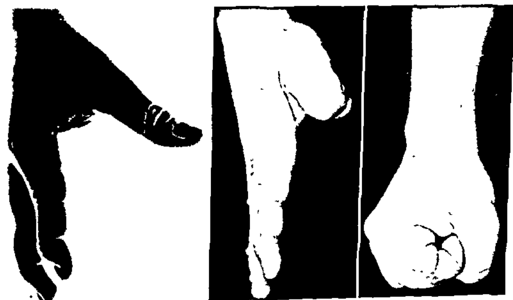


Fig. 2. (*Left*) Appearance of the *hand before* surgery. Note the deformity in the index finger. There is a hyperextension of the proximal interphalangeal joint, and total extension of the distal phalanx is impossible (*Center*) Appearance of the hand 2 months *after surgery*. The deformity has disappeared completely. Both the index and the middle finger are fully extended, and there is no hyperextension of the proximal joint (*Right*) There is full flexion of the fingers into the hand and a normal grip

(Figs. 1 C & 2, *left*). The patient was incapacitated from work as operator of a tabulating machine, as both fingers, the index and the middle, were in the way all the time.

Both fingers were corrected in 2 stages. The middle finger was operated upon first and the index finger 6 weeks later, the same technic being used in each case. By means of a tourniquet and local anesthesia, an incision was made over the interphalangeal crease at the radial surface of the finger. The extensor mechanism was dissected carefully, both aponeurotic bands, the medial and the lateral, being isolated. These bands were found to be displaced toward the dorsal aspect of the finger, which caused a disorder of the delicate mechanism and the deformity here described (Fig. 1 C). It was also observed that when the patient was asked to flex his finger, it produced a great laxity in the bands that displaced them more toward the dorsum of the finger and did not give the necessary tension to extend the distal phalanx completely, which was the cause of the deformity in hyperextension of the proximal interphalangeal joint.

The object of this operation was to reposition the bands toward the axis of the finger, close to the capsule, in such a fashion as to obtain more tension and enable total extension of the distal phalanx. This was done by suturing the bands in their new position with No. 000 chromic catgut. Care was taken to place the bands as much as possible toward the volar part of the finger. With the bands in their new position, the patient was asked to extend the finger. Immediately the deformity was corrected (Fig 1 D).

Both operative wounds healed *per primum*, and 2 months after the operation the hand was normal with full extension of the distal phalanx and full flexion of the two fingers operated upon (Fig 2, *center & right*). A year and a half after operation the hand remains normal and the patient works without difficulty.

SUMMARY

We have reported a case of congenital deformity of the lateral bands or slips of the extensor mechanism of 2 fingers that produced a flexion deformity of the distal phalanx and a hyperextension deformity of the proximal interphalangeal joint. A brief review of the anatomy shows the importance of the lateral bands in the delicate mechanism of the extensor apparatus of the finger.

The patient was operated on under a tourniquet and local anesthesia. Correction consisted of placing the bands as much as possible toward the axis of the finger and close to the capsule in such a way that tension was increased. Suturing was done with chromic catgut. As soon as the bands were anchored in their new position, the deformity disappeared and the patient was able, at the moment of correction during operation, to flex and extend his finger without any difficulty.

REFERENCES

1. Bunnell, Sterling: Surgery of the Hand, ed. 3, Philadelphia, Lippincott, 1956.
2. Grant, J. C. Boileau: An Atlas of Anatomy, ed. 3, Baltimore, Williams & Wilkins, 1951.
3. Gray, Henry, and Goss, C. M.: Anatomy of the Human Body, ed. 25, Philadelphia, Lea & Febiger, 1948.
4. Nichols, M. H.: Manual of Hand Injuries, Chicago, Year Book Pub., 1955.
5. Testut, L.: Tratado de anatomía humana, vol. 1, ed. 7, Barcelona, Salvat, 1922.

25

Thumb Traction Again

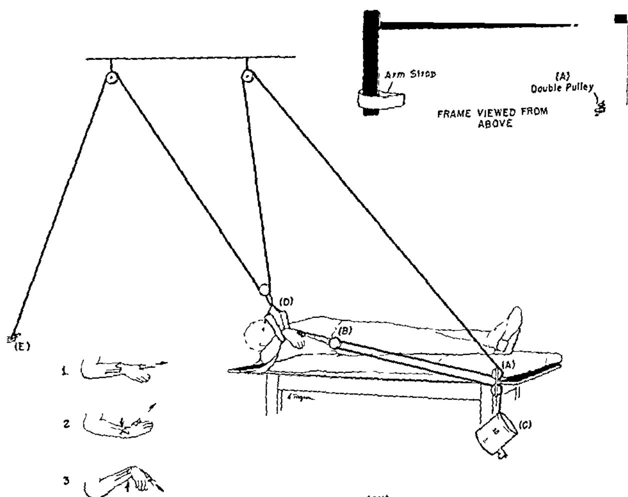
THOMAS F. BRODERICK, JR., M.D.*

An adaptation of thumb traction has proved to be very satisfactory in the management of Colles and forearm fractures over the past 8 years. A compound hyphenated description might be the Russell-Rose-Saint Elizabeth's Slow Drip Method.†

* Orthopaedic Service, Saint Elizabeth's Hospital, Boston, Mass.

Briefly, two double-pulley systems are set up: two of these are fixed to the ceiling, and the other pair (A) is incorporated in a frame which is anchored by the patient's

† Brit. J. Surg. 11:491-502, 1924.



For explanation see text.

weight. This simple frame, which is reversible for right and left, was devised by Dr. Edward Mitiguy who, as anesthetist, has done many brachial blocks through the rigging. A single pulley (B) is attached to the thumb by a clove hitch of flannel bandage, and another single pully (D) is fixed to a spreader which holds a felt sling immediately proximal to the fracture site. Weight (C) consists of 5 lbs. of water in a bucket with a stopcock outlet. Horizontal traction is initiated by anchoring the rope at (E). This is maintained for from 8 to 10 minutes, after which reduction is effected by first depressing and then elevating the fracture site. Dorsiflexion and ulnar deviation are maintained by snugging up the rope at (E). Anterior and posterior plaster splints are applied incorporating the felt sling, and, while these are setting, the traction is released gradually by allowing water to drip out of the stopcock. Any desired veering of the vectors can be obtained by moving the table and its three pulleys in relation to the other four fixed points.

This method appears to be complicated, but actually it makes the setting of a Colles fracture almost as simple as 1, 2, 3.

26

Neuroma of Plantar Digital Nerve

A New Method of Treatment

LEWIS COZEN, M.D.*

Metatarsalgia caused by a neuroma of the plantar digital nerve is a common orthopaedic complaint.[1,3] Usually the diagnosis is not difficult. The patient gives a history of sharp, lancinating pain in the forepart of the foot, radiating into the toes, usually the third and the fourth. The pain is caused by the development of a neuroma of the plantar digital nerve. This neuroma can cause excruciating pain that radiates up into the calf and, indeed, into the entire leg. A characteristic detail in the history is that the patient says that he feels better as soon as he takes off his shoe.[5,6] When the foot is examined, point tenderness can be elicited in the web between the toes, usually the third and the fourth, but sometimes between the fourth and the fifth or the second and the third. Another diagnostic aid is the elicitation of a painful click as the metatarsal heads are pressed together. As Mulder[4] has pointed out, the click without the pain probably has no pathologic significance, but, when pain is elicited, then one can assume that the painful neuroma is squeezed out between the metatarsal heads.

At times redistribution of pressure over the metatarsal area helps. This can be done by means of a metatarsal bar attached to the sole of the shoe behind the metatarsal heads, by a metatarsal pad inside the shoe behind the metatarsal heads and by metatarsal exercises.[2] If these methods fail, the usual course is to excise the neuroma through either a plantar or a dorsal incision.

Before resorting to surgical excision, I have found one other method of treatment to be of value in some cases. This consists of the injection of hydrocortisone, 0.5 cc., into the region of the neuroma between the metatarsal heads. The injection was tried in 17 cases, and acceptable relief of pain was obtained in twelve.

The results were evaluated as being acceptable relief of pain when the patient said that his pain was relieved at least 50 per cent. Each patient acted as his control, in that he had pain until the time of injection, and in most cases the pain would recur to a lesser degree after 1 to 2 weeks following the injection When the injection then was repeated, further diminution of pain was obtained in the cases classified as being acceptable. The number of injections for each patient varied from one to eight, usually at weekly intervals. Hydrocortisone, ½ cc., was injected in the web space between the metatarsal heads, in most cases between the third and the fourth metatarsals For two patients metatarsal bars were ordered, but in the remaining cases no auxiliary method of treatment was used in order to prevent any additional confusion of the results.

* Los Angeles, Calif

RELIEF OBTAINED FROM INJECTION OF HYDROCORTISONE INTO THE REGION OF THE NEUROMA BETWEEN THE METATARSAL HEADS IN 17 CASES

PATIENT	MEDICATION	RESULT
M. W.	Hydrocortone	"Much better": 6-month follow-up
J. L.	Xylocaine and Hydrocortone	"No improvement at all — injection hurt": 3-month follow-up
A. A.	Hydrocortone	"Not 100% — 50% better": 5 months later
R. A.	Hydrocortone	"Improved": 1 year later
A. H.	Bars, exer. sugg. surgery Hydrocortone	"Much better": 2-year follow-up
I. T.	Hydrocortone	"Much better, but not all gone": 1-year follow-up
B. P.	Hydrocortone	"Improved — pains gone but still have metatarsal callus": 18-month follow-up
P. P.	Hydrocortone	"Improved — relieved": 2-year follow-up
H. R.	Hydrocortone	"Better — avoids callus": 8-month follow-up
E. C.	Hydrocortone	"No relief": 1-year follow-up
L. F.	Hydrocortone	"No relief": 2-month follow-up
R T.	Xylocaine and Hydrocortone	"Better after Hydrocortone": 8-month follow-up
M P.	Hydrocortone	"Improved — first relief in 3 years": 1-week follow-up
D S	Hydrocortone, TBA	"No relief": 3-week follow-up
L. S.	Hydrocortone, TBA	"No relief": 6-month follow-up
W. G	Hydrocortone, TBA	"Excellent relief": 6-month follow-up
S. G.	Hydrocortone	"75% relief": 3-month follow-up

One patient especially acted as a satisfactory control. A neuroma had been removed from her other foot 2 years earlier, so that there was little question of the accuracy of the diagnosis. She obtained satisfactory relief of pain, although she required 6 injections. On one occasion, 1 cc. of 2 per cent Xylocaine was injected instead of the Hydrocortone This gave her no relief after the local effect of the Xylocaine wore off, in contradistinction to the relief of pain that she obtained from the Hydrocortone.

SUMMARY

Seventeen patients with neuroma of the plantar digital nerve were treated by injection of Hydrocortone in the region of the neuroma. Twelve of the patients obtained acceptable relief from the injections. It would seem that this method should be added to the conservative program of treatment before surgery is performed.

REFERENCES

1. Betts, L. O.: M. J. Australia 1:514, 1940.
2. Cozen, L.: Office Orthopedics, ed. 2, Philadelphia, Lea & Febiger, 1953.
3. McElvenny, R. T.: The etiology and surgical treatment of intractable pain about the [illegible]
4. [illegible] in Morton's metatarsalgia, J. Bone & Joint Surg. 33-B:95, 1951.
5. Nissen, K. I.: The etiology of Morton's metatarsalgia, J. Bone & Joint Surg. 33-B: 293, 1951.
6. Winkler, H., Feltner, J. B., and Kimmelstiel, P.: Morton's metatarsalgia, J. Bone & Joint Surg. 30-A:496, 1948.

27

Partially Threaded Round Pins with Oversized Threads for Intramedullary Fixation of the Clavicle and the Forearm Bones

LOUIS W. BRECK, M.D.*

The author considers a strong round pin to be the best method of intramedullary fixation in clavicle, radius and ulma. These three bones are shaped differently on cross section from one end to the other, and, if a pin other than a round one is used, there is some tendency for the fragments to warp in rotation as the pin goes down the medullary canal. A pin of adequate strength is absolutely essential to prevent the breaking or the bending of the pin. A great advantage of the pins described here is that the oversized threads at the end are very effective in preventing either inward or outward migration of the pin. The small square end over which the Bohlman key fits is advantageous in facilitating the introduction and the subsequent removal of the pin.

HISTORY AND DESCRIPTION

Essentially, the present pins are a modification of the Bohlman pin. Oversized threads are employed to prevent migration. The square end is placed on the pin to facilitate its introduction. This square end employs the same key or tubular chuck as that used with the Bohlman pin. Usually the author prefers an elongated version of this key as it is much easier to use deep down in the tissues.

The pin is a modified regular stainless steel Steinmann pin ⅛ inch in diameter. It comes in a length of 12 inches. One end of the pin has oversized threads for a distance of 1 inch. The very tip of the pin has a square end which fits the regular Bohlman key or wrench. Use of the square tip makes it much easier to insert the pin and to remove it subsequently. The purpose of the oversized threads is to prevent inward or outward migration. In actual use the pin usually is left buried under the skin, and the skin is sutured over it. Besides the ⅛th inch diameter, the pin is obtainable in a diameter of 7/64th inch for use in particularly small clavicles or forearm bones. In inserting the pin, the key used with the Bohlman pin may be placed in an ordinary hand drill, a heavy hand drill, or even a power drill if desired, although this is not recommended particularly.

TECHNIC IN THE CLAVICLE

An open reduction, exposing the fracture site, is done. The smooth portion of the pin is drilled forward as far into the proximal fragment as is felt desirable to establish an adequate path for the pin to get a secure grip on the fragment. Usually 1½ inches is enough. An extra ⅛ inch of free path at the end is allowed for impaction later on The pin then is removed from the frac-

---

* El Paso, Texas.

ture site and drilled the other way until it comes out through the cortex of the distal fragment and reaches the skin. An incision is made through the skin to allow the pin to come clear through. Next, the pin is taken out again at the fracture site. Careful measurements are made so that an adequate amount of the unthreaded portion of the pin will be present in each fragment. The pin now is cut off to proper length. The cut end is filed blunt to remove any burrs formed when it was cut. It is then placed through the small lateral incision into the distal fragment, through the distal fragment across the fracture site and into the proximal fragment. When the threaded portion reaches the cortex of the distal fragment, it is carefully engaged and threaded into this cortex, at least ½ inch purchase being got on it. It is advanced by means of a hand drill. The remainder of the threaded portion of the pin is cut off if necessary. In many instances it is not necessary to cut off any excess if the distal fragment is long enough. With this technic, secure intramedullary fixation is obtained, and the procedure is done with pre-



Fig. 1. Roentgenogram of the special intramedullary pin in the clavicle.

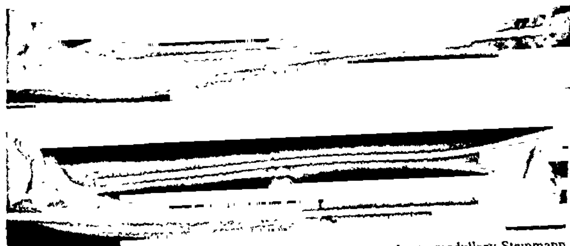


Fig. 2. Roentgenogram of the forearm showing the special intramedullary Steinmann pins in the radius and the ulna. Note that the port of entry in the radius is the styloid, and in the ulna it is the olecranon.

cision. The oversized threads prevent migration of the pin. Both incisions are closed, and the pin thus is buried. Removal of the pin from 4 to 6 months after operation is optional with the surgeon.

TECHNIC IN THE FOREARM

In employing this technic the fracture should be opened. In the ulna, the pin is run up the medullary canal proximally and passed out through the point of the olecranon. A small incision is made here. The pin then is removed from the medullary canal at the fracture site, and the pointed end is put through the olecranon. Next it is passed down the shaft of the ulna across the fracture site. When the threaded portion of the pin contacts the olecranon, it is carefully drilled and threaded into the bone at this point to hold the pin securely. A 1-inch threaded portion should be engaged in the olecranon of the ulna.

In using this technic in the radius, the fracture site is opened to make sure that adequate reduction is obtained. The pointed portion of the pin then is inserted carefully through the area of the radial styloid. A small incision is made to do this. The wrist is placed in strong ulnar deviation. Care is taken to avoid the wrist joint. In inserting this pin, usually it is better to insert a smaller pin first to establish a path. The final pin is advanced up the shaft of the radius, well across the fracture site. When the threaded portion engages the area of the styloid, it is carefully drilled and threaded in a distance of at least 1 inch. In fractures both of the ulna and the radius, the length of the pin should be measured, cut and filed before the pin is inserted. It is desirable to have at least 3 inches of purchase in the shorter fragment. An important part of this technic is not to immobilize the patient in a cast or other fixation apparatus for more than 3 weeks after the operation. The patient should be encouraged to us his hand, although very vigorous use should not be permitted.

In using these pins, the standard large size usually is employed. However, in individuals with very small medullary canals, the smaller-sized pin is better. In the author's experience, it has been very much better to leave the pins in from 1 to 2 years if it is at all possible in order to make absolutely sure that union is quite solid and that restoration of the cortex is complete before removing them. The square end on the pin makes it relatively easy to remove.

BIBLIOGRAPHY

Böhler, L.: Medullary Nailing of Kuntscher, first English edition, Baltimore, Williams & Wilkins, 1948.

Bohlman, H. R.: Personal communication, March, 1958.

Eggers, G. W. N., Schindler, T. O., and Pomerat, C. M.: Influence of contact-compression factor on osteogenesis in surgical fractures, J. Bone & Joint Surg. 31-A:693-716, 1949.

Kuntscher, G.. Intramedullary nailing: experimental study, Klin. Wchnschr. 19:6-10, 1940.

McKeever, D. C.: Personal communication, 1944 (intramedullary Steinmann pins in forearm fractures).

Orr, H.: Treatment of fractures by means of skeletal devices, with fixation in plaster-of-paris casts, J.A.M.A. 98:947-951, 1932.

Rush, L. V., and Rush, H. L.: Technique for longitudinal pin fixation of certain fractures of ulna and of femur, J Bone & Joint Surg. 21:619-626. 1939.

28

Certain Observations from Abduction Studies of the Shoulder

LEE A. HADLEY, M.D.*

A roentgenogram of the normal shoulder made with the patient lying supine, the hand in full supination and the arm lying alongside the body shows the greater tuberosity in profile (Fig. 2, *center*).

The roentgenogram of a normal shoulder made with the arm raised to the full limit of abduction and the hand remaining supinated will show the greater tuberosity to have passed beneath the acromium (Figs. 1, *right*, & 2, *right*). Usually the humerus becomes aligned with the spine of the scapula.

In certain cases of painful shoulder from *bursitis, synovitis, tenosynovitis* or *periarthritis*, with or without calcific deposits, the greater tuberosity appears to impinge against the undersurface of the acromium. These roentgenograms are made at the full limit of forced passive abduction with the palm up (Fig. 1, *left*). The impingement may be, in part at least, the result of muscle spasm.

As shown in Figure 1, *left*, this impingement may occur even without abnormal calcification. In a painful shoulder with calcification, the calcification itself may cause the impingement (Fig. 2, *left*). Even a large dense calcification, however, if painless, may cause no impingement whatever. The calcification in that case appears to become displaced forward or backward out of the way when the arm is raised (Fig. 3, *left & right*).

* Syracuse, N. Y.



FIG. 1. Female, 54 years of age. (*Left*) Acute shoulder pain, passive abduction restricted. Greater tuberosity impinges against undersurface of acromium. (*Right*) Complete recovery 9 months later. The patient now is able to dip the greater tuberosity beneath the acromium in a normal manner.



FIG. 2. Female, 50 years of age. (*Left*) Roentgenogram made at full abduction. Impingement of the calcification in the soft tissue prevents passage of greater tuberosity beneath acromium. (*Center*) Spontaneous resorption of calcium 6 months later without specific treatment. (*Right*) Complete recovery of abduction after resorption of calcium. The greater tuberosity now dips beneath the acromium normally.



FIG. 3. Female, 36 years of age. (*Left*) Large dense calcification in the soft tissues. Painless shoulder, arm in adduction (*Right*) Arm in abduction, movement not hindered by the large calcification.

Often a dense calcification undergoes spontaneous absorption without the use of any specific treatment (Fig. 2, *left* & *center*).

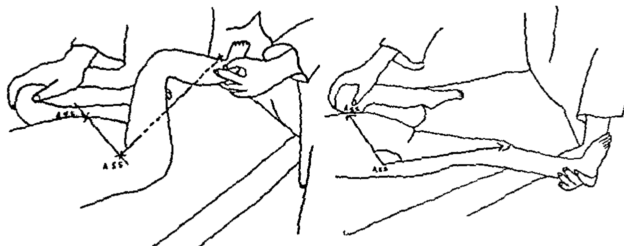
Abduction studies are useful in the evaluation of intrinsic shoulder pain. The method also is helpful in recording the progress of recovery (Figs. 1, *right*, & 2, *right*).

29

Test for Contracture of the Iliotibial Band

MORTON H. LEONARD, M.D.

Contracture of the iliotibial band in the postpoliomyelitic state is common. The usual test is Ober's. An easy way to discover this tightening is to test for hip flexion contracture with the joint in abduction and then in neutral position. If a hip flexion contracture is present when the thigh is perpendicular to the level pelvis, and this contracture is relieved as the hip is abducted, there is tightening of the iliotibial band (*see* figure).



(*Left*) Thomas test with hip neutral. Note flexion contracture.
(*Right*) Thomas test with hip abducted. Flexion relieved Iliotibial band tight.

30

Refracture of Ununited Medial Malleolus

EUGENE R. MINDELL, M.D., AND WILLIAM J. ROGERS, 3RD, M.D.*

Fractures of the medial malleolus that result in fibrous union may lead to satisfactory ankle joints. This is particularly true in sedentary individuals. However, no report is found in the literature of the result of subsequent fracture to an ankle with a preexisting fibrous union of the medial malleolus. Two such cases are reported here.

Case 1. A 59-year-old housewife was first seen on October 3, 1954, a few hours after she had injured her right ankle. The heel of her shoe caught when she was coming downstairs, and she fell and twisted her ankle. She had immediate pain and deformity, and the right ankle soon swelled. On examination the ankle was found to be moderately swollen, and the foot was displaced laterally into a valgus position. Roentgenograms of the ankle (Fig. 1) demonstrated fresh fractures of the medial and the lateral malleoli, and a fracture of the posterior lip of the tibia. The distal fragments and the foot were displaced laterally.

Careful examination of the roentgenogram demonstrated an old ununited fracture of the medial malleolus. The recent fracture of the medial malleolus was proximal to the old fracture. The patient stated that she had fallen from a stepladder in 1921 and suffered a fracture of this ankle. The injury then was treated by plas-

* University of Buffalo School of Medicine, Department of Orthopaedic Surgery.



FIG. 1. Roentgenograms of the right ankle demonstrate recent fractures superimposed on an old nonunion of the medial malleolus.

ter immobilization for 6 weeks. She made an excellent recovery from this injury. Once or twice a year she would "turn the ankle" and experience a little soreness for an hour or two. She had been able to do housework and had had no significant disability until the recent injury.

The ankle fracture was reduced by manipulation, the fracture fragments were restored to satisfactory position (Fig. 2), and a long leg plaster dressing was applied. Immobilization was maintained for a total of 10 weeks.

At the present time the patient walks well without a limp. She had had only an occa-



FIG. 2. Roentgenograms demonstrate satisfactory reduction of the fracture fragments in plaster immobilization



FIG 3. Roentgenograms made 1½ years after patient's recent injury demonstrate that union of the recent fractures had occurred. Note the persistence of the nonunion of the medial malleolus. This patient walks well without pain or limp



FIG. 4. Roentgenograms of the left ankle demonstrate recent fractures and the presence of an old fibrous union of the medial malleolus.

sional ache in her ankle, and all activities have been resumed. On examination very slight swelling of the ankle is noted. An excellent range of painless ankle motion and subtalar motion is present. Final roentgenograms (Fig. 3) show the recent fracture to be well united in excellent position. The old fibrous union of the medial malleolus is unchanged.

Case 2. A 58-year-old housewife fell when she turned her left ankle on a curb on October 3, 1951. She described the ankle as being painful, swollen and obviously displaced. Examination revealed swelling of the ankle with the foot displaced laterally and in moderate valgus. Roentgenograms revealed fresh fractures of the medial and the lateral malleoli, and a fracture



FIG. 5. Roentgenogram demonstrates satisfactory reduction in plaster immobilization.



Fig. 6. Roentgenograms of left ankle made 3½ years after injury. Recent fractures are healed, but the old fibrous union of the medial malleolus persists.

of the posterior lip of the tibia. The distal fragments with the foot were displaced laterally. An old ununited fracture of the medial malleolus was also present distal to the recent fracture, and apparently was undisturbed by the recent injury (Fig. 4). The patient had had a compound fracture dislocation of this ankle 17 years previously. This was treated by plaster dressing immobilization for about 7 weeks. She had recovered completely from this injury without residual symptoms, and her ankle appeared to be normal until the recent injury.

The fracture fragments were manipulated into satisfactory position, and a long leg plaster dressing was applied (Fig. 5). Immobilization was maintained for 14 weeks, the last 5 of which were in a short leg walking cast. The patient has been followed for 3½ years and has a very satisfactory ankle. However, it is slightly larger than [illegible]
degrees of [illegible]
The patient [illegible] fort, but it does not interfere with her normal activities.

These two cases demonstrate the adequacy of fibrous union of the medial malleolus in middle-aged women, 33 and 17 years, respectively, after ankle fractures. In each instance subsequent trauma of sufficient severity occurred to produce fractures of both malleoli and the posterior lip of the tibia. The new fracture of the medial malleolus was immediately proximal to the old fibrous union. The pseudarthrosis was undisturbed Union of the recent fractures occurred readily. The old fibrous union of the medial malleolus remained unchanged. Excellent function was regained and has been maintained over follow-up periods of 1½ years and 3½ years, respectively.

31

Skeletal Fixation of the Pelvis in the Correction of Hip Flexion Contractures*

W. R. HAMSA, M.D., D. W. BURNEY, M.D., AND WARREN J. ROBERTS, M.D.

The anatomic relationship of the pelvis to the spine and the femora is dictated by the forces exerted upon it by muscular attachments and origins. The pelvis drifts with any predominant force until an equilibrium is reached. Normally, this position is a tilt of 45° to 60°, known as the angle of inclination. Any disturbance of this balance of forces, whether paralytic, congenital or traumatic, is prone to disturb this position with a tilt toward this predominant force. This is particularly true during growth and may occur with minor imbalance. As Irwin[2] has

* From the University of Nebraska College of Medicine, Nebraska Orthopedic Hospital, and the Bishop Clarkson Memorial Hospital.

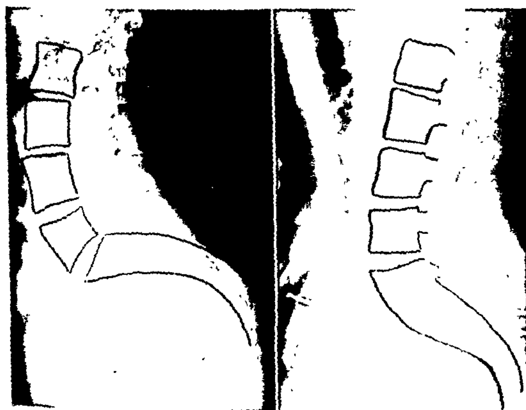


FIG. 1. Lateral of lumbosacral spine, hips extended to 180°, before and after correction.

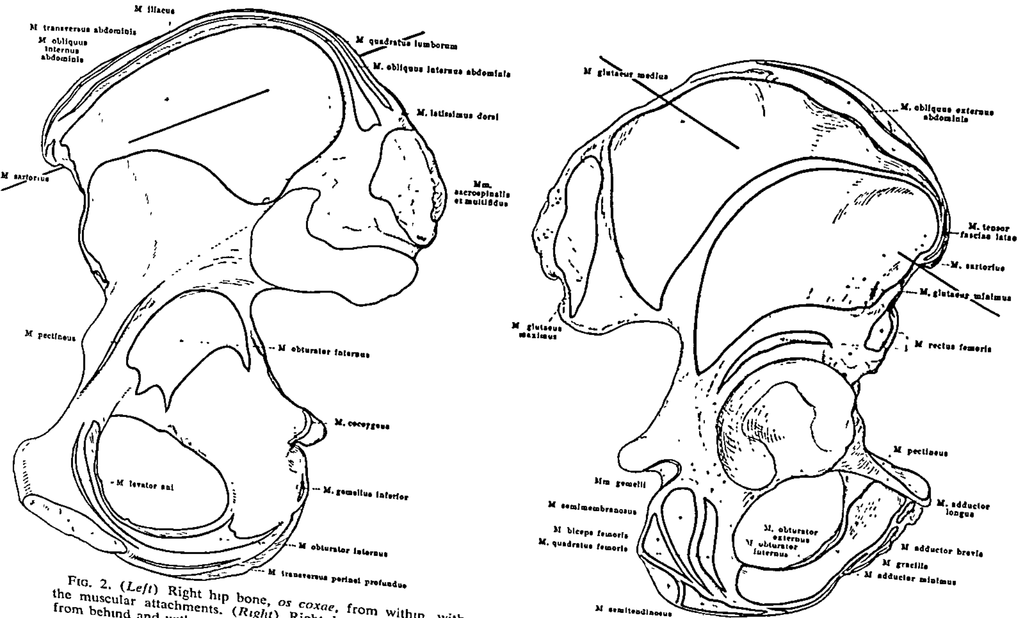


FIG. 2. (*Left*) Right hip bone, *os coxae*, from within, with the muscular attachments. (*Right*) Right hip bone, *os coxae*, from behind and without, with the muscular attachments. Inner and outer views of ilium to illustrate approximate location and direction of Steinmann pin. (Spalteholz, W.: Hand Atlas of Human Anatomy, ed. 5, Philadelphia, Lippincott)

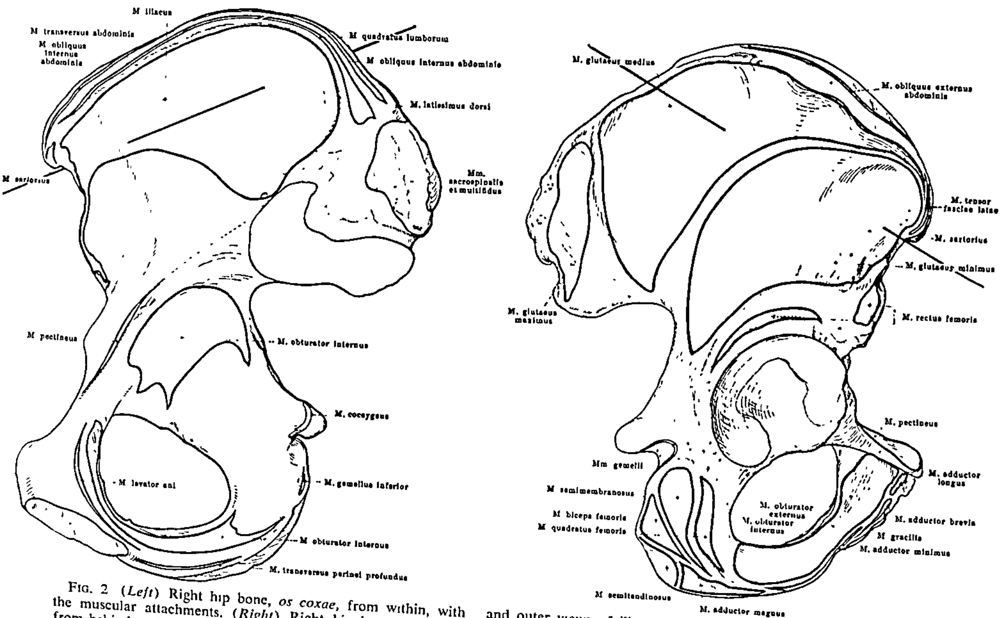


FIG. 2 (*Left*) Right hip bone, *os coxae*, from within, with the muscular attachments. (*Right*) Right hip bone, *os coxae*, from behind and without, with the muscular attachments. Inner and outer views of ilium to illustrate approximate location and direction of Steinmann pin. (Spalteholz, W.: Hand Atlas of Human Anatomy, ed. 5, Philadelphia, Lippincott)

pointed out, a minor disturbance of muscle balance may produce contractures about the pelvis, of the hip and, on occasion, of the knee and the foot.

Exclusive of compression, force and its direction can be applied to the pelvis only through the medium of attached skeletal and muscular structures. Extension force applied in the treatment of flexion contractures of the hip joint also produces undesirable extension in the lumbosacral region with associated increased angle of pelvic inclination. Following surgical release of hip flexor contractures,[1,4,5] hip extension is more efficient in the degree of correction at the hip joint but is still associated with the secondary increased lumbosacral lordosis and postoperative abdominal stretch symptoms described originally by Stewart.[6] This is the result of inability to control movement of the pelvis. Dame Hunt partially solved the problem by using the opposite lower extremity in full flexion as a lever to immobilize the pelvis while extending the contracted hip joint.[5] More recently, Irwin demonstrated an improved method of pelvic control following release of contractures of the iliotibial band. In all these methods force is applied indirectly to the pelvis.

Noting the mediocre result obtained in the occasional marked hip flexion contracture release treated by these methods, attempts were made to apply postoperative force directly to the pelvis in 5 patients. Stainless-steel wire sutures were inserted into the region of the anterosuperior iliac spines with traction directed anteriorly and superiorly. It was difficult to anchor these to the cast and cut through bone with minor force. The insertion of 3½-inch stainless-steel screws into anterior and posterior iliac spines bilaterally with 1½ inches protruding from the skin was much more efficient; their insertion posteriorly, however, presented a technical difficulty or necessitated turning the patient into the prone position (Fig. 1). More recently a 9-inch stainless-steel pin $\frac{5}{32}$ inch in diameter has been drilled diagonally across the ilium after completion of the surgical correction. It is inserted inferior and

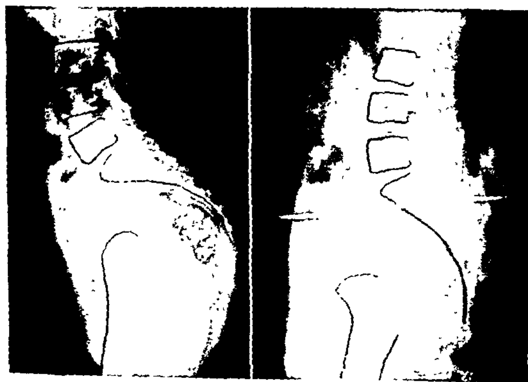


Fig. 3. Similar views, using Steinmann pin.

lateral to the anterosuperior iliac spine, and passes through the ilium superiorly, medially and posteriorly to the iliacus side. A periosteal elevator lifts the iliacus muscle to allow pin progression without danger to peritoneum. The pin emerges a few inches posteriorly through the ilium to the gluteus maximus side, where it penetrates the skin (Fig. 2). Optimal bony fixation is obtained by drilling the pin's exit through the ilium immediately below the thicker crest; a more inferior exit may allow the pin to cut through the thinner ilium when flexion forces are applied. Mechanically this pin then serves as a lever attached to the pelvis, which may now be flexed on the spine by direct force (Fig. 3). Insertion of a pin into each side may be advisable in marked contractures.

The details of cast fixation postoperatively are most important. Both hips are flexed to the original position while a padded, well-molded body cast is applied, the desired position of the pelvis being maintained by force applied to the screws or the protruding ends of pins. These are incorporated in the cast. When the plaster hardens, this relationship of pelvis to spine will be retained. Both hips now are extended fully, and a double long leg spica cast completes the procedure. As the pelvis cannot rotate within the cast, overcorrection into hip hyperextension is not necessary. The postoperative course is characterized by much less abdominal distention due to the absence of stretching of anterior abdominal wall and of abdominal viscera. The cast has been removed in 4 weeks. Signs of skin irritation about the protruding pin necessitated removal of pin through cast windows after 2 weeks in 1 patient without material loss of position of the pelvis.

SUMMARY

A method of pelvis fixation in the treatment of marked hip flexion contracture is described. The anatomic relationship of the pelvis to the spine is maintained by skeletal fixation before the hip joints are extended, thereby preventing anterior tilting of the pelvis with its exaggerated lumbar lordosis.

REFERENCES

1. Campbell, W. C.: Transference of crest of ilium for flexion contracture of the hip, South. M. J. 16:289-292, 1923.
2. Irwin, C. E.: The iliotibial band; its role in producing deformity in poliomyelitis, J. Bone & Joint Surg. 31A:141-146, 1949.
3. Mercer, Walter: Orthopedic Surgery, ed. 4, p 510, Baltimore, Williams & Wilkins, 1950.
4. Ober, F. R.: The role of the iliotibial band and fascia lata in causation of low back disability and sciatica, J. Bone & Joint Surg. 18:105-110, 1936.
5. Soutter, Robert: A new operation for hip contractures in poliomyelitis, Boston M. & S J 170:380-381, 1914.
6. Stewart, S. F : Post-operative care of flexion contracture of the hip, J. Bone & Joint Surg 4:549-552, 1922.

32

The Orthopaedic Surgeon Looks at Traffic Safety

MILTON C. COBEY, M.D., F.A.C.S.*

The automobile has come to be the foremost cause of bone and joint injuries in this country today. Either directly or indirectly, a great portion of the work required of the orthopaedic surgeon now is the result of automobile accidents. For this reason, in a preventive way, the orthopaedic surgeon should interest himself actively in the cause and the prevention of automobile accidents, and particularly those which produce bone and joint damage. Through the President's Traffic Safety Committee, which now is active in the prevention of accidents, work is being done nationally. Therefore, the orthopaedic surgeon should contribute by bending his energies and applying his knowledge to the methods of prevention of accidents and, should they occur, to their early treatment.

The prevention of accidents has been fostered somewhat by the automobile manufacturers and very definitely by the state and the federal governments in the construction of highways. Automobiles have been improved a great deal, and, while a great deal of criticism can be leveled at the manufacturer on the score of accidents and death, he certainly has made an effort to make the automobile safer. He has been aided in his work of automobile safety by Cornell University's Automobile Crash Injury Research Department, which has demonstrated the type of injuries produced by different of crashes. Through their punch-card r systems, statistics are being collected ra These statistics now are of great help i taining information on all types of inj The information is supplied by accide vestigation forms. These now are mad in most of the states, and a copy is t in to the Cornell unit. This method o lecting and cataloguing information i best plan for accurate study of the mobile accident. For example, a cru injury to the chest with fracture of the num and the ribs was shown to hav curred in a head-on collision. From t was possible to arrive at a so-called b away steering wheel. When a certain an of force is placed upon it, this wheel give in such a way as to minimize damage to the chest from either the ri the wheel or the spoke of the steering At the moment figures are being com by this organization as to the value o safety steering wheel.

Since 1956 many fatal injuries have prevented as a result of the applianc safety door latches to all cars. Fata prior to that time occurred because o fact that on impact the doors flew open cupants were thrown free of the car, a many instances the injuries that would been fractures of the extremities or the were fatal because the patient was struc an oncoming vehicle. According to the nell Auto Crash Research Department

* Professor of Orthopaedic Surgery, Georgetown University School of Medicine.

safety door latch has reduced the number of fatalities and, perhaps, the morbidity. Recently, the author treated a massive injury of the chest in which all 24 ribs were fractured, as well as the scapula and the spine. When the car was struck, the driver's door sprang open and the driver was thrown forcibly onto the concrete. Massive injuries like this can be treated for shock. Pleural and cardiac effusions may be aspirated. Life may be saved temporarily. The over-all picture still is critical, as often these patients succumb from 3 to 7 days later. Despite the liberal use of blood to restore a falling hematocrit and the splinting of the back with a board and a felt mattress, the blood does not dialyze in the kidney. Eventually the patient succumbs to an apparent uremia. A real advance has been made by the artificial kidney. Dr. George Schreiner[3] has saved several lives in this critical period by its use. The artificial kidney is a dialyzing agent in which, under sterile technic, the blood is bathed in fluid which is relatively isotonic. This will restore the more nearly normal blood chemistry and often the kidney will regain function after from 1 to 6 treatments.

Fractures of the cervical spine have been reduced by the use of the cushion dashboard and the breakaway windshield. Some automobile manufacturers install them routinely now. The individual thrown forward from the back seat will strike the windshield horizontally. From the front seat, where his body will bounce, he will strike the windshield at the upper edge of the body frame, causing either the skull to fracture or the neck to break. As the body bounces from the front seat, the heavy rigid frame under which the upper portion of the windshield attaches becomes a hazard. Some cars now carry the windshield far enough back so that the head will strike the windshield rather than this frame bar across it. The care of the fracture of the cervical spine is as in all cervical fractures. However, it should be borne in mind that often the upper cervical vertebra is involved and life is endangered in moving the patient from the scene of the accident or caring for him when he is first admitted to the emergency room unless head traction is applied immediately.

The cushion dashboard is of dual importance, in that the individual may be thrown directly forward and the knees come in contact with the dashboard.[2] The femoral fracture occurs when the hips and the weight of the body slide forward against the dashboard. Should the legs be in adduction—for example, when the knees are crossed—forcible thrust against the knee of the dashboard in rapid deceleration will cause the force to pass directly up the femur to the acetabulum. This adducted position of the femur will cause the hip joint to dislocate. The head will be thrust forcibly behind the acetabulum; or a fracture of the neck of the femur will occur, or a fracture of the posterior rim of the acetabulum with a dislocation of the femur. If the leg is in abduction—in other words, if the individual is sitting with the legs wide apart at the time of the accident—an interpelvic protrusion fracture of the acetabulum may result. If the legs are straight ahead, usually there will be a comminuted fracture of the femur with fracture of the patella Therefore, padding of the dashboard becomes extremely important.

Compression fractures of the lumbar spine have been attributed both to the use of seat belts and to the lack of them. Of course, seat belts do prevent the body's rising to the frame of the car and causing fractures of the cervical spine. The question as to whether or not seat belts cause a flexion fracture of the bodies of the vertebra is a moot point. It is true that the jackknife injury does cause compression fractures of the spine, but, so far as can be ascertained, the seat belt does not cause these injuries. Apparently, the occupant flexes at the pelvis and the hips rather than at the mid-spine. The belt prevents the forward thrust of the body into the windshield or the dashboard, protecting the head, the cervical spine and the femora from fracture. It is true that

patients who have been injured while wearing a seat belt have had compression fractures of the spine. This has been reported by John O. Moore, research associate of the Cornell Research Department, who has this to say about safety belts: "It is our opinion that it is the most important single device that is available for all automobiles in a price range that can be afforded by the average car owner." The author feels that, if it is learned that a seat belt was used at the time of the accident, it might be wise, in examining the patient for various injuries following the accident, to check the spine more carefully for possible fracture.

A number of agencies have been very active from a medical standpoint in efforts to further research in the development of highways, the engineering of automobiles and safety measures for the protection of the human being. Outstanding in this is the Trauma Committee of the American College of Surgeons, which holds an annual meeting, and this subject has real importance in the discussion of methods to be laid before the automobile manufacturers, the automobile associations and even legislative bodies to prevent this serious traumatic situation. When one considers that in 1954 there were 952 deaths due to poliomyelitis and 40,000 to automobile accidents, with a proportionate morbidity, the automobile accident becomes as important to the orthopaedic surgeon as the effects of anterior poliomyelitis.

The District of Columbia chapter of the Trauma Committee of the American College of Surgeons has worked out a manual for the use of the house officers in the emergency rooms of the various hospitals of the District of Columbia This manual, entitled "Principles of First Aid for Traumatic Cases in the Emergency Room of a Hospital,"[1] covers all the specialties in a single-page form. What to do for each type of injury—how to suture lacerations, to treat shock and to care for eye injuries, as well as to treat injuries to the genito-urinary tract and other parts of the body, besides fractures, sprains and other bone and joint trauma—is outlined in brief. This is done so simply that a quick 3-minute review by the house physician warns him of the danger points. It has been the feeling of many orthopaedic surgeons that the patient is damaged not so much by the rescue squad as by the ambulance and the emergency treatment in the emergency room. The first-aid courses given by the American Red Cross and practicing physicians instructs ambulance personnel pretty well in the care of the victim on the highway. Also, many courses given by agencies instruct the general public in the care of the patient on the highway. Often the patient is brought to the emergency room in very good condition. On the other hand, medical students are not given intensive courses in trauma in many institutions, and because of this the principles of first aid and the emergency care of the patient are either forgotten or overlooked. Often the zeal of the young doctor in trying to determine the injury will blind him to the prevention of shock and trauma to other parts by the application on admission of a simple Thomas splint. The rush to the x-ray for a roentgenogram to see the fracture may end up with the patient in profound shock because splinting was neglected. This little book is the "pause for reflection" for the house officer in order that the critical step of admission to the hospital, splinting and emergency care, restoration of fluid loss, and the prevention or the treatment of shock can be carried out as a lifesaving measure. Excellent methods of care once the patient has been hospitalized have been developed. Definitive treatment for all types of fractures and injuries to muscles, nerves, ligaments and soft parts is far superior today to what it was. The mortality is greatly reduced and, even more so, the morbidity. Patients now ambulate early; time was when they would be months in bed. That step from the ambulance to the bed for definitive treatment is a critical and an important one.

The Traffic Committee of the District of Columbia Medical Society acts as an advisory agent to the District government Police Traffic Department. Its job is to evaluate emotionally and physically the ability of drivers to operate a motor vehicle. Once a driver has had an accident or has run afoul of the law in some other way and his license is suspect or has been suspended for medical reasons, this committee must restore the license or else revoke it completely for medical causes. Now, through this same committee efforts are being made to establish with the National Institute of Health a research program that will study the emotional stability of the driver so that he will not become an accident statistic. Emotional stability of the automobile driver is a very important factor, for he may be a Doctor Jekyll until he gets behind the wheel of a car, when he becomes a veritable Mr. Hyde.

At this time definitive care of the fracture has progressed to the point at which it is highly important for the orthopaedic surgeon to carry out specific technics. Casting material has progressed from the early days of ordinary plaster of Paris to acetic acid plaster of Paris and now to the melamin resin plasters. These last render casts that are strong and less likely to break and do not absorb moisture from the wound. Cast material now is relatively clean chemically, so that infections will not develop from the plaster. Internal fixations such as plates and screws have been improved; they do not irritate bone or break as easily as formerly. Finally, as is well known, intramedullary fixation is receiving rapidly increasing acclaim.

The use of other adjunctive materials should be remembered. The artificial kidney has been mentioned. The course of treatment of an individual requiring the artificial kidney is interesting. The Orthopaedic Department at the Georgetown University Hospital has worked closely with the other departments in the care of injured. When a person is severely injured and can be splinted only by means of skin or skeletal traction until his general condition warrants definitive orthopaedic surgery, the use of supporting measures by the hematology department as well as the adjunct surgical services is important. Those individuals so badly hurt that they required the artificial kidney to prevent death have been restored to life. During the time that they were in this moribund state, often unconscious for weeks and requiring as much as eight 8-hour visits to the artificial kidney until the contused and damaged kidneys were able of themselves to begin functioning, fractures showed no evidence of union. One case was followed for a period of 9-weeks before definite treatment of his bilateral femora or metatarsal fractures of his feet could be carried out. Only traction and temporary plastic cast splinting could be used. During this period of time no bone union whatsoever occurred. This probably was due to reduced kidney function and to lack of the normal protein being carried to the fracture sites. However, once the patient began to have normal kidney function and was in such a condition as to stand intramedullary fixation of a fractured femora, plating of a tibia and reduction of metatarsal bones in both feet with the application of plastic casts, the fractures began promptly to unite and healed with excellent results This is a new finding and a new report, and bears out the extreme importance of proper splinting during this period of extreme shock. It also demonstrates the value of the artificial kidney.

As an orthopaedic surgeon and a member of the President's Traffic Safety Committee, the Trauma Committee of the American College of Surgeons and the Medical Advisory Committee to the Traffic Department of the District of Columbia Police Force, the author feels that the following recommendations should be made.

1. Careful investigation of the accident should be pursued as to make of car, body style and condition of the highway so that the research department record division of

the Cornell Traffic Safety Research can continue to function.

2. Efforts should be made by orthopaedic surgeons to aid in stimulating state and federal legislatures to build dual highways, and this present period of recession would be a particularly good time to carry this out.

3. The automobile manufacturers should be persuaded to co-operate by use of the safety belt, the breakaway steering wheel, the breakaway windshield, the safety door locks, the cushion and padded dashboard and, if possible, tubular construction of the frame for additional strength, as well as by continued automotive research.

4. Speed limits should be set on the bases of the condition of the road; they should not be a blanket state directive. Some roads lend themselves to higher rates of speed than others. In some instances laws prohibit sensible rapid driving, and these laws stimulate the driver to drive too fast in order to make up for time lost.

5. The police should not only be uniformed but have well-marked cars, both to encourage the driver to adhere to the law and to facilitate the movement of traffic.

If orthopaedic surgeons will co-operate along these lines, the result should be a decrease in the mortality and, possibly, in the severity of fractures and other injuries encountered. The slow driver is a hazard, piling up traffic behind him, and it is the duty of the police to see that such a driver moves at a proper speed or to send him to a checking station for investigation.

REFERENCES

1. Principles of First Aid for Traumatic Cases in the Emergency Room of a Hospital, prepared by Region Committee on Trauma of the District of Columbia of the American College of Surgeons
2. Ritchey, S. J., Schonholtz, G. J., and Thompson, M. C.: The dashboard femoral fracture *in* Am. Acad. Orthop. Surgeons Instructional Course Lectures, vol. 15, 1958.
3. Schreiner, George: Specific therapy for salicylism, New England J. Med. 253:213-217, 1955.
4. ———: Hemodialysis and effective therapy for acute barbiturate poisoning, J.A.M.A. 161:820-827, 1956.

The Traffic Committee of the District of Columbia Medical Society acts as an advisory agent to the District government Police Traffic Department. Its job is to evaluate emotionally and physically the ability of drivers to operate a motor vehicle. Once a driver has had an accident or has run afoul of the law in some other way and his license is suspect or has been suspended for medical reasons, this committee must restore the license or else revoke it completely for medical causes. Now, through this same committee efforts are being made to establish with the National Institute of Health a research program that will study the emotional stability of the driver so that he will not become an accident statistic. Emotional stability of the automobile driver is a very important factor, for he may be a Doctor Jekyll until he gets behind the wheel of a car, when he becomes a veritable Mr. Hyde.

At this time definitive care of the fracture has progressed to the point at which it is highly important for the orthopaedic surgeon to carry out specific technics. Casting material has progressed from the early days of ordinary plaster of Paris to acetic acid plaster of Paris and now to the melamin resin plasters. These last render casts that are strong and less likely to break and do not absorb moisture from the wound. Cast material now is relatively clean chemically, so that infections will not develop from the plaster. Internal fixations such as plates and screws have been improved; they do not irritate bone or break as easily as formerly. Finally, as is well known, intramedullary fixation is receiving rapidly increasing acclaim

The use of other adjunctive materials should be remembered. The artificial kidney has been mentioned The course of treatment of an individual requiring the artificial kidney is interesting The Orthopaedic Department at the Georgetown University Hospital has worked closely with the other departments in the care of injured. When a person is severely injured and can be splinted only by means of skin or skeletal traction until his general condition warrants definitive orthopaedic surgery, the use of supporting measures by the hematology department as well as the adjunct surgical services is important. Those individuals so badly hurt that they required the artificial kidney to prevent death have been restored to life. During the time that they were in this moribund state, often unconscious for weeks and requiring as much as eight 8-hour visits to the artificial kidney until the contused and damaged kidneys were able of themselves to begin functioning, fractures showed no evidence of union. One case was followed for a period of 9-weeks before definite treatment of his bilateral femora or metatarsal fractures of his feet could be carried out. Only traction and temporary plastic cast splinting could be used. During this period of time no bone union whatsoever occurred. This probably was due to reduced kidney function and to lack of the normal protein being carried to the fracture sites. However, once the patient began to have normal kidney function and was in such a condition as to stand intramedullary fixation of a fractured femora, plating of a tibia and reduction of metatarsal bones in both feet with the application of plastic casts, the fractures began promptly to unite and healed with excellent results. This is a new finding and a new report, and bears out the extreme importance of proper splinting during this period of extreme shock. It also demonstrates the value of the artificial kidney.

As an orthopaedic surgeon and a member of the President's Traffic Safety Committee, the Trauma Committee of the American College of Surgeons and the Medical Advisory Committee to the Traffic Department of the District of Columbia Police Force, the author feels that the following recommendations should be made:

1. Careful investigation of the accident should be pursued as to make of car, body style and condition of the highway so that the research department record division of

the Cornell Traffic Safety Research can continue to function.

2. Efforts should be made by orthopaedic surgeons to aid in stimulating state and federal legislatures to build dual highways, and this present period of recession would be a particularly good time to carry this out.

3. The automobile manufacturers should be persuaded to co-operate by use of the safety belt, the breakaway steering wheel, the breakaway windshield, the safety door locks, the cushion and padded dashboard and, if possible, tubular construction of the frame for additional strength, as well as by continued automotive research.

4. Speed limits should be set on the bases of the condition of the road; they should not be a blanket state directive. Some roads lend themselves to higher rates of speed than others. In some instances laws prohibit sensible rapid driving, and these laws stimulate the driver to drive too fast in order to make up for time lost.

5. The police should not only be uniformed but have well-marked cars, both to encourage the driver to adhere to the law and to facilitate the movement of traffic.

If orthopaedic surgeons will co-operate along these lines, the result should be a decrease in the mortality and, possibly, in the severity of fractures and other injuries encountered. The slow driver is a hazard, piling up traffic behind him, and it is the duty of the police to see that such a driver moves at a proper speed or to send him to a checking station for investigation.

REFERENCES

1. Principles of First Aid for Traumatic Cases in the Emergency Room of a Hospital, prepared by Region Committee on Trauma of the District of Columbia of the American College of Surgeons.
2. Ritchey, S. J., Schonholtz, G. J., and Thompson, M. C.: The dashboard femoral fracture *in* Am. Acad. Orthop. Surgeons Instructional Course Lectures, vol. 15, 1958.
3. Schreiner, George: Specific therapy for salicylism, New England J. Med. 253:213-217, 1955.
4. ———: Hemodialysis and effective therapy for acute barbiturate poisoning, J.A.M.A. 161:820-827, 1956.

Index